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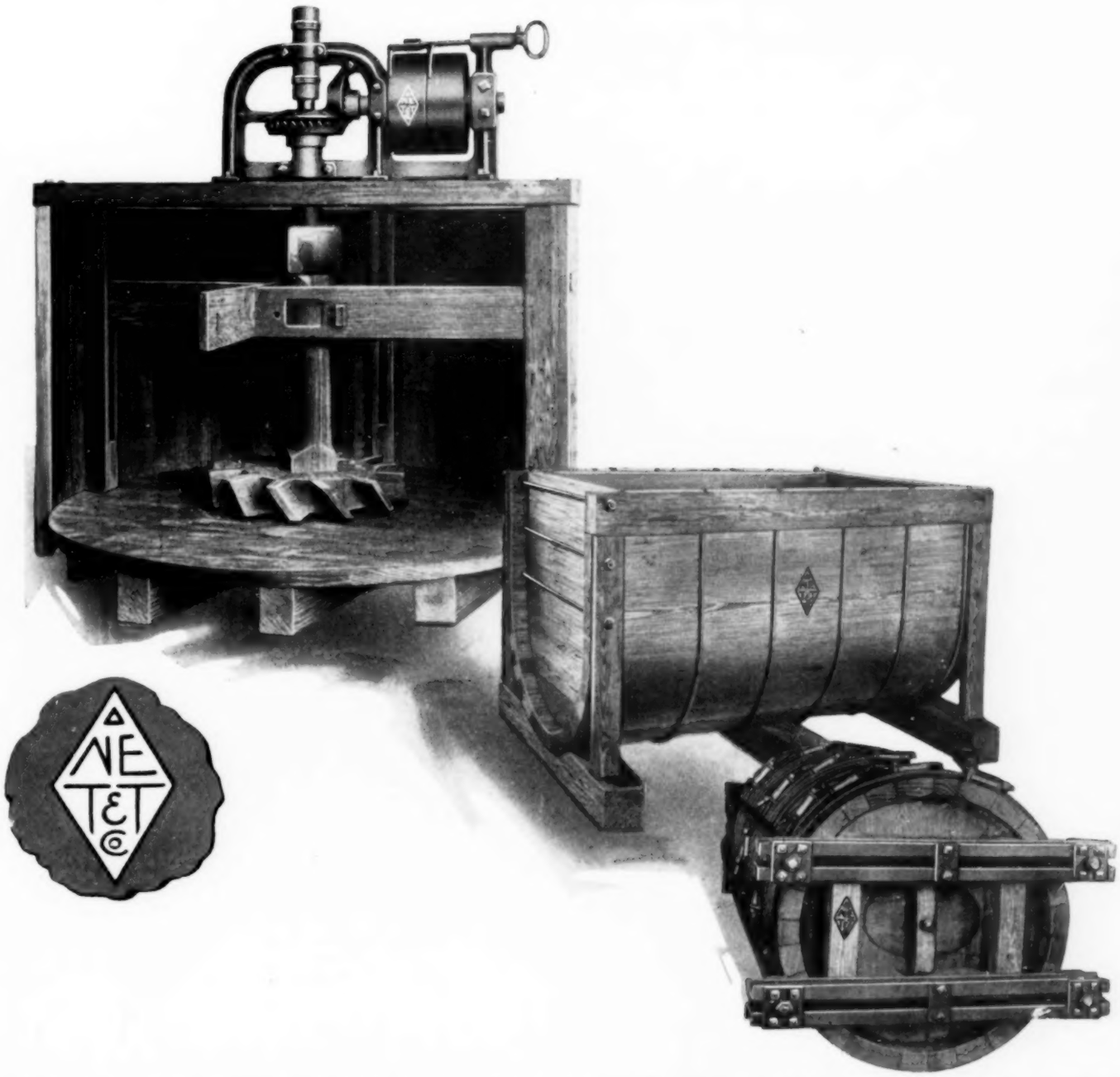
CHEMICAL & METALLURGICAL ENGINEERING



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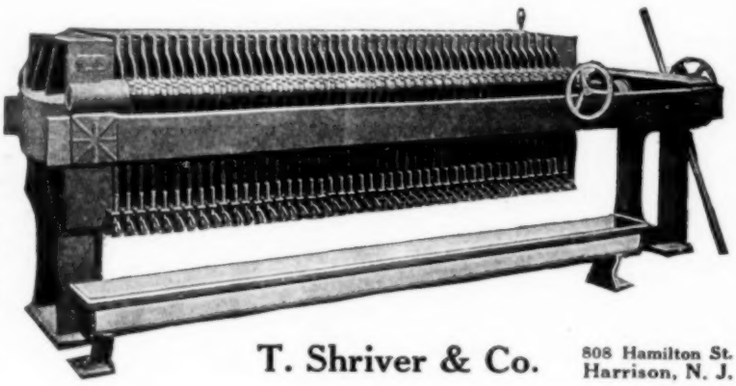

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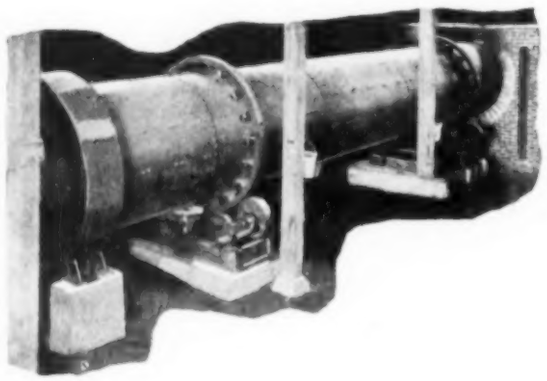

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Perkin Medal for Doctor Whitney

THE award of the Perkin Medal to Dr. WILLIS R. WHITNEY, director of the research laboratory of the General Electric Co., will meet with universal approval which will only be heightened by the doctor's generous attempts at self-effacement. He was the unanimous choice of the Committee on Award. Dr. WHITNEY may protest that he cannot graciously accept the medal as a personal tribute and that he shines in the accumulated glory of members of his staff. But even in this recognition of his loyal associates, Dr. WHITNEY'S admirers will find indirect though ample justification for the honor that has come to him. Accepting for the moment his disclaimer to personal achievement, which the record will not sustain, his name is synonymous with one of the first and most successful organizations for industrial and scientific research. This in itself is no light accomplishment, and if Dr. WHITNEY prefers to let his claim to fame rest thereon his friends will still feel that it is quite sufficient to warrant his present recognition.

Senate Muddles The Nitrate Bill

AFTER several weeks of debate on the bill to create the United States Fixed Nitrogen Corporation the Senate passed it in amended form on Jan. 14. It will be recalled that the purpose of this bill was to provide the necessary corporate machinery for federal ownership and operation in the interest of the War Department of the nitrate plants at Muscle Shoals. As the Senate discussion grew in volume the fog in which the entire subject has been enshrouded increased in density until there was little likelihood that the Senate could emerge from it with any intelligent action. One has only to read the debate in the *Congressional Record* for the past few weeks to confirm the forecast which we made months ago when we intimated that on account of the complexity of the subject, the dust created in the course of discussion probably would obscure and defeat the legitimate ends of the bill. The nitrogen question is many-sided. Even if one had to deal only with its economics and technology, the subject would be large enough. But when, as in the present instance, it is so intimately mixed with politics, public and private, there is little hope of intelligent action.

It is true that economic and industrial conditions have changed since the bill was introduced a year ago and it is quite possible that it needed amendment. But such amendments as Senator WADSWORTH introduced on Jan. 4 could have but one purpose and effect—namely, to kill the bill. Their full purport is not evident at this writing, but one of them takes the jurisdiction of the plant out of the War Department and puts it in the Treasury. Another increases the corporation's financial obligations to the United States by requiring it to issue bonds up to half of the war-time expenditures of the Government in constructing the nitrate plants and for the full value of the hydro-electric installation if and when acquired by the corporation. This has been done in spite of the fact (or maybe in accord with it) that persistent opponents of the bill have testified to Congressional committees that the Plant No. 2 could not possibly be sold for anything like its war-time cost nor even leased on any such basis.

The amendments can scarcely be taken in good faith, because they require the corporation to earn 5 per cent on its securities under penalty of ceasing operations and awaiting further action by Congress. This would kill it in its first year of operation. It would also compel it to operate the plants at the greatest capacity and enter into the stiffest kind of competition with commercial fertilizer manufacturers—something that never was contemplated by any of those who have advocated the control and operation of the plants by the War Department. One of the objections to that control and operation was that the peace-time product of the plants must inevitably compete with certain articles of domestic commerce, and objection was raised to the United States engaging in such competition. The current amendments practically impose upon the corporation the necessity of engaging in such competition, if it is to maintain its existence.

In the consideration of this, as of many other technical subjects with which Congress has to deal, we are repeatedly impressed with the value of the much-maligned "single-track" mind. It is far superior to the "sidetrack" mind which seems to develop in large number and great variety whenever a complicated question is before our national legislature. In the present instance the issues have been so misrepresented, distorted and complicated that the original and legitimate reasons for and purposes of the bill have been lost to sight. Let us keep them clearly in mind. The United States has made a large investment in plants for nitrogen fixation at Muscle Shoals. The Chief of Ordnance is charged with securing and maintaining an adequate supply of munitions for the Army; and at present, as in the past, his only source of nitrate is in a foreign country, Chile. There is no nitrogen-fixation industry now actively functioning in this country, capable of furnishing the Chief of Ordnance with a supply of nitrate in case of emergency. From this point of view and this one alone, CHEMICAL & METALLURGICAL ENGINEERING has seen sufficient justification for the creation of some agency for the utilization of the Muscle Shoals plants by the War Department. Until there is an active nitrogen-fixation industry in this country which can function for the Ordnance Department in case of emergency, just as the steel industry can and does, the Government is justified in controlling so complete an agency for the production of nitrate as the plants at

Muscle Shoals. The purpose of such control and operation is nitrogen preparedness. If the original provisions of S. 3390 will not accomplish this purpose, let us discover and support some other measure that will. In our judgment the bill might as well die as pass in its amended form, because the corporation could not possibly function under the conditions imposed. Let us not forget that the issues involved relate primarily to national welfare. From that viewpoint it is inconceivable that after our war experience we should be guilty of the indefensible folly of dependence on Chile.

Chemists May Become Chemical Ambassadors

THE chemical profession needs more ambassadors in industry. Not chemical politicians, not talkers and salesmen of the chemical idea, but rather ambassadors who, by their action in everyday business relations, individually propagandize the doctrine of technical control of plant operations. The number of men available for this work is large, but few hold to the thought.

Between the two fields of chemical activity—pure research on one hand and betterment of industry on the other—it rests with the individual chemist to choose. Should he decide on the former he is to be congratulated, for all the delights of meandering through the dreamland of technical philosophy, all the honors for original discoveries, all the pleasures of independent thinking and of exploration for new ideas, will be his. The beauty of nature's contour, color and music, and all man-made imitations of these, are formless, achromatic and discordant compared to the joyous travels of the inner scientific mind.

But all cannot follow this beacon light of pure science. The majority must occupy themselves with industry; for industry must eventually support research, that research, in turn, may advance industry. Pure science burdened with sordid matters of money cannot climb the peaks. The great host traveling the industrial highway have, however, one ideal in common—namely, that the chemist may become the top executive with each business organization so he can properly apply the principles of his partner, the research man, to the forwarding of the industry in question.

Accomplishment of this object demands that he seemingly depart far from the ways of theoretical science while inwardly clinging to the ideal. For industry thrives best on practical common-sense sort of procedures. On leaving school after a year or two occupied in a rounding out of the theoretical side of his training, the chemist should enter the production department of his chosen industry and start a new training in common sense. He will learn to appreciate that a large amount of work has been done even by rule-of-thumb methods, and see how he may gradually inculcate technical procedure without disturbing the financial equilibrium of the plant operations. He should never forget that he is the servant of the stockholders, who are vitally interested in cash profits.

Many times a new invention cannot be immediately adopted because of the enormous loss involved in scrapping the equipment of the less remunerative process. If a man were hungry and had only the price of a baking oven, he would not buy the oven but rather spend the money on flour and fuel to make his bread by the open fire. New apparatus is often nice but too expensive. Plain thinking rules industry.

The Opportunist In Research

EXPERIENCED research directors of real achievement condemn the opportunist in research, for such a man will do only that which he sees as promising for increased dividends tomorrow. He cannot see as far ahead as next week and he never thinks of the problems of next year. The condemnation of the opportunist is, indeed, frequent among those who really know how to organize and carry through a research program. On the other hand, the commendation of one who knows how to plan and "gets away with it" is not so frequent, though fully as well deserved. It is a pleasure, therefore, to emphasize examples of successful far-seeing research programs.

One of the most striking examples of this sort recently came about in the work of the research division of a large organic chemical corporation whose name is known throughout America wherever the language of chemists is spoken. This research division had under way for several years a program of investigation for which it had been rather criticized by the management of the company. How the director of research managed under the circumstances to keep the work going is a secret which he alone could tell. But in any event he did so.

The reward of the effort which had been made through several years came in full measure recently. With changing relation between costs of materials, the expense for wages and the margin of profits possible in the plant processes, this corporation found it wholly impracticable to continue upon the war-time basis of plant operation. The directors threw up their hands in horror at the situation. They were virtually helpless when confronted by the new industrial problems. That they were thoroughly terrified by the situation is evident by the fact that they took the initiative in consulting the director of research as to what they should do. Then it was that they learned the purpose of all the research upon which they had previously frowned. They found it possible to abandon the old processes which had previously been financially successful, even to the extent of scrapping equipment and structures on an extensive scale. The new program promises to be even more handsomely successful than the old, simply because the research department had fully worked out through all stages of laboratory and semi-commercial scale the industrial requirements of a new economic situation.

Had this corporation been successful in discouraging the far-sighted research program and had the program of an opportunist been insisted on, it is very doubtful whether the research staff could possibly have answered the appeal when this distressing situation was encountered by the management. Some other organizations, which have not been so sympathetic in research and development work upon a scale suited to *long* periods of successful plant operation, can only take their losses and hope that their conversion to the newer thought may be sincere and permanent. If they are not converted fully, they can rest assured that they will sooner or later be eliminated from consideration. With conditions which demanded close figuring only the best processes and the most efficient utilization of byproducts and wastes can successfully continue under present conditions in competition with other well-planned and scientifically-controlled business.

Presentation of Perkin Medal to Willis R. Whitney

Addresses Made at the Fourteenth Award of the Perkin Medal by the Society of Chemical Industry—Personal Remembrances by Elihu Thompson and Arthur D. Little—Presentation by C. F. Chandler—Acknowledgments and "The Biggest Things in Chemistry" by Willis R. Whitney

THE fourteenth Perkin Medal presentation meeting of the American Section of the Society of Chemical Industry was held in Rumford Hall Friday evening, Jan. 14. In the course of his introductory remarks Sumner R. Church said: "It is my own privilege as chairman of the Medal Committee to state simply that at the meeting when the selection was made there was no word spoken save in unanimity of choice. Since then we have heard no words save of approval and heartfelt pleasure concerning this award. I can testify that Whitney's example has inspired every man in this country who has to do with the direction of chemical research. Whenever he could he gave freely of his time to advise and encourage those who visited him, however slight their claims might be."

Twenty Years of Research

Prof. Elihu Thompson gave an excellent review of the work of the General Electric research laboratories, using as an illustration the development of the incandescent lamp. The original carbon filament lamp was not very satisfactory. When operated at a temperature which gave a high ratio of light to energy input, the vapor pressure of carbon was so high that carbon was condensed too rapidly on the bulb. The physical properties of carbon were somewhat improved in the G-E-metallized filament which was the basis of the G-E-M lamp. Tantalum, molybdenum, osmium and tungsten were investigated successively. Coolidge's process for making tungsten ductile so that standardized wires could be drawn is the foundation of the modern incandescent lamp industry.

Biographical Reminiscences

By Arthur D. Little

From the point of view from which I see this audience it is in the main a gathering of young men. To them I am glad to say that years bring their compensation. It is pleasant to be able to remember the fiftieth anniversary of the discovery of mauve, to recall its modest and benign discoverer, to have participated in the festivals which were designed to do him honor and to have shared the desire to perpetuate the memory of that discovery and its momentous consequences by the foundation of the Perkin Medal.

Someone has said that an institution is the elongated shadow of a man. Never was this more true than in the case of the General Electric Laboratory. Its achievements have been discussed with authority by Prof. Thompson and will be fully itemized by Dr. Chandler. They are the work of many men to whom they have brought deserved distinction. None the less, the laboratory as the entity and organization which has made this achievement possible is a projection of the personality of Willis R. Whitney, and in this sense its achievements are his achievements.

Whitney returned from Europe in 1896 with a Ph.D. from Leipzig. He had left home a good American and he came back a truer one. He had absorbed in Germany what were then advanced and difficult theories in chemistry and physics and to their application to the solution of chemical and industrial problems he now brought vision and a contagious inspiration. To him a problem was an opportunity and his reaction to it was as reflex and immediate as a knee jerk. I remember that he once told me after a pleasant dinner in Syracuse, when the conversation had reached the eternal verities, that he didn't want to go to heaven unless there were problems there.

Naturally, therefore, he began at once the brilliant experimental work which has added much to our knowledge of solubility, colloids and the corrosion of metals. His fundamental research demonstrated the effect of the positive and negative ions on the precipitation of colloids. He found that the corrosion of metals was an electrochemical process and he was perhaps the first to focus public attention upon the great economic wastes resulting from preventable corrosion.

Whitney is a pragmatic scientist, and the essential and innate practicability of his mental processes found early expression in the successful method which he developed in association with Dr. A. A. Noyes for the recovery of ether and alcohol from collodion, a process which not only assured the commercial position of the photographic film, but which also in its subconscious and later influence upon the mind of Mr. Eastman undoubtedly played its part in effecting that gentleman's reincarnation as the mysterious and benevolent Mr. Smith to whom the Massachusetts Institute of Technology owes its present superb equipment.

I happen to know, for I had the honor of making the bid, that prior to 1900 he refused a doubled salary and remained an instructor at Technology, because he "would rather teach than be President." At the time I thought it an extraordinary example of devoted self-denial, but since then I have seen what happens to our Presidents and I would, without self-adulation, take the same position myself, much as I hate teaching.

Academic Life

Dr. Whitney's relation to the Massachusetts Institute of Technology has been intimate and concurrent with his professional career. Immediately upon graduation, in 1890, he was appointed assistant instructor in sanitary chemistry in that institution. He had, we may assume, no strong directive impulse toward that branch of the science, but he demonstrated at once his characteristic ability to adapt himself to the job, and with it to identify himself. In 1892, by the slow process of academic preferment, he was promoted to instructor, but after serving for two years his desire for the advanced training and broader contacts with the scien-

tific world then offered by Germany caused him to enter the University of Leipzig. Upon his return to the Institute in 1892 he was appointed instructor in theoretical chemistry and proximate analysis. Fortunate indeed were those students whose schedule brought them under his influence. It would be interesting to know how many of them appreciated the quality and recognized the potentialities of their instructor.

He became, in 1901, assistant professor of theoretical chemistry, in 1904 non-resident professor of theoretical chemistry, and in 1908 non-resident professor of chemical research. More recently he has become a member of the Corporation of the Institute and he has served as chairman of its committee on the department of chemistry and chemical engineering, and is now active as chairman of the committee on the department of physics. It is a matter of general comment and satisfaction within the instructing staff that he has never lost interest in the school. Visiting committees of the Corporation too often do not visit. But Dr. Whitney came upon the job determined to know its every aspect. He spent days in the laboratories. He sat down by students; into them he injected his own enthusiasm. He studied the needs of the departments and he followed his studies by helpful suggestions and constructive criticism.

Ideal Characteristics

One very conspicuous element in Whitney's character is the sincerity of his indifference to monetary rewards. It is the more striking because of the clarity with which he visualizes the economic aspects of research results. He went to the General Electric Co., as I confidently believe, not for money, but because it offered an environment and opportunity for broader and more effective service. I am no less confident that he would return to Tech. tomorrow and readjust his expenditure within the narrow boundaries of a professor's salary if he felt that there he could do a better job.

I wonder how many of you have realized how closely in appearance Whitney resembles Lizst. One expects of him—and is not disappointed—the same fire and enthusiasm, a kindred brilliancy of performance, a similar exothermic quality. Whitney can talk to a man three minutes and inject into him enough enthusiasm to last three months. He can recognize genius and he is big enough to allow the man of genius to develop at his side. He has no wish and makes no effort to dominate. He scrupulously apportions credit where it belongs. Jealousy is alien to his nature. These are the characteristics of the ideal director of research, and it is because they are possessed in superlative measure by Willis R. Whitney that we are present here tonight.

Human Elements

Willis R. Whitney is a great scientist, but he is not the scientist of fiction or of the stage. He is an intensely human individual. He is extremely fond of outdoor life and it keeps him sane and wholesome. He is a farmer, not a gentleman farmer but a dirt farmer who knows hog cholera and manure and what to do when his hens have the pip. He has hobbies and rides them. He can tell you more about arrowheads than an Algonquin Indian ever knew, and if necessary he can make them. He usually prefers to pick them up in Central Park or Long Acre Square, or at church. He can find them anywhere. He enjoys the lighter things of life and has even been known to sidestep a meeting of the American Academy of Arts and Sciences, and go to a girl and music show instead. Biological subjects (and I am not now referring to those just mentioned in association with music) interest him keenly. He raises flies and kills them with X-rays to cure their cancer. Some day he may kill the cancer first. He is a serious student of heredity and knows exactly how much red hair is required to tint a large family unto the third and fourth generation. But do not let me convey the impression that Whitney approaches these vocational interests in the spirit of the dilletante. His knowledge of them is not broad and thin, it is both broad and deep. When he cultivates a subject, he does it intensively with all the energy in him. Better than all this, however, Whitney has a genius for friendship. He knows you but likes you.

With this interest in his fellowmen so dominant and characteristic, it is not surprising that Whitney should have proved an ideal teacher or that no later absorption has turned his thought from education. He inspires whole departments in the Massachusetts Institute of Technology; he is the prime mover of Albany Medical College, and as trustee of Union College at Schenectady has so tied his laboratory to the college that they constitute a joint educational institution.

In a very striking way and more nearly, as it seems to me, than any of his contemporaries, Whitney has the mental attitude and scientific breadth of an earlier generation in the scientific world, the ability to correlate and integrate observations and deductions in wide and different fields.

The Perkin Medal is the badge of knighthood in American chemistry. It has never been more worthily bestowed. Its latest recipient has inspired numberless young men; he has brought distinction to a great corporation and proved to financiers that research pays; he has brought new luster to American chemistry. The spirit of research has laid her hands upon him, and the spirit of youth as well.

Presentation Address

By C. F. Chandler

It is my privilege and very pleasant duty as senior past-president of the Society of Chemical Industry, residing in this country, to present to Willis R. Whitney, S.B., Ph.D., the fourteenth impression of the Perkin Medal, in recognition of his most original and valuable work in applied chemistry.

Dr. Willis R. Whitney was born in Jamestown, N. Y., Aug. 22, 1868, and was the son of John and Agnes (Reynolds) Whitney. He was graduated from the Massachusetts Institute of Technology with the degree of S.B. in 1890, and in 1896 received the degree of Ph.D. from Leipzig.

Research Laboratory of the General Electric Co.

His most notable achievement has been the creation and development of the Research Laboratory of the General Electric Co. at Schenectady. This laboratory, one of the earliest of its kind in this country, the embodiment of the application of science to industry, has gained a world-wide reputation by the quality of its work and the importance of its results. These results speak for themselves, but only those associated in the laboratory with Dr. Whitney can realize to what extent they are due to him personally, or how truly the story of the laboratory, from its inception with

a small staff to its present development with 275 people on its payroll, has been the story of his personal achievement. Its growth has followed naturally from the value of its accomplishment, but its accomplishment has been due primarily to him. His broad scientific knowledge, his ability as a chemist, his resourcefulness in experiment, his energy, enthusiasm and optimism, combined with a clear sense of proportionate values, laid the foundation for, and guided and inspired, all the work of the laboratory, while his democratic and magnetic personality created an *esprit de corps* in his staff which has been a powerful factor for success. This must be realized fully to appraise justly his personal achievements in considering the success of the laboratory.

These successes have often been recited specifically to prove the value of the application of organized research to industry. In electric lighting the first radical improvement in the carbon incandescent filament, since Edison first produced it, was due to Dr. Whitney's personal work. The "metallized" filament, or "Gem" lamp, which he developed and which embodied a new form of carbon, gave 25 per cent more light for the same wattage than the standard carbon filament lamp. Millions of these new lamps were sold in a single year. A little later the laboratory made a still greater contribution to electric lighting, by solving the problem of mechanically working tungsten and taught the world how to make the drawn wire which has given the tungsten lamp its universal application. The latest achievement of the laboratory in incandescent lighting is the gas-filled or half-watt lamp, which, in its larger sizes, has twice the efficiency of the vacuum lamp, and nearly equals the most efficient arcs. In arc lighting the laboratory developed the magnetite electrode, and thereby produced the most successful arc lamp of today.

W. R. WHITNEY

The laboratory has produced many new and useful forms of insulations and molded compounds, many new alloys for resistance units and other purposes, new processes, like "calorizing," for giving metals protective coatings; new articles of manufacture, like "sheath wire," with its core of resistance alloy, its mineral insulation and its metal sheath, adapted for heating devices; new materials, like "water japan" and "Genelite"; new electric-furnace products, like boron carbide, useful as a flux for casting copper, and titanium carbide for arc lamp electrodes; new laboratory tools, such as the Arsem vacuum furnace, the tungsten tube furnace and the Langmuir condensation vacuum pump; high-resistance units for lightning arresters, improved carbon and graphite and Metite brushes.

The development of wrought tungsten has been followed by several important applications worked out entirely in the laboratory. Tungsten contacts have practically replaced platinum in spark coils, magnetos and relays, and tungsten targets have replaced platinum in X-ray tubes.

As a result of a study of high vacuum, the laboratory devised means and methods for producing much higher vacua than before obtained, and the study of the phenomenon of electron discharge in high vacuum has produced a number of new types of vacuum tubes which have revolutionized more than one art. The Coolidge X-ray tube was the earliest result of this investigation and has practically displaced all other types of X-ray tubes. It has made possible many results not otherwise obtainable, as, for instance, the development of a truly portable X-ray outfit. Another result was the pliotron, the first real power tube suitable for radio transmission. The pliotron practically created radio telephony and has revolutionized radio telegraphy. Other types of these tubes resulting from this investigation are the dynatron, magnetron, pliodynatron, etc. The contributions of the laboratory to pure science have been numerous, varied and important, as is indicated by the titles taken from the list of laboratory publications:

Factors Affecting Relations Between Photo-electric Current and Illumination.
Structure of the Atom.
Theory and Use of the Molecular Gage.
Theory of Unimolecular Reaction Velocities.
Absorption and Scattering of X-Rays.
New Method of X-Ray Chemical Analysis.
New Method of X-Ray Crystal Analysis.
Roentgen-Ray Spectra.
High-Frequency Spectrum of Tungsten.
Arrangement of Electrons in Atoms and Molecules.
Chemical Reactions at Low Pressures.
Constitution and Fundamental Properties of Solids and Liquids.
Dissociation of Hydrogen Into Atoms.
Effect of Space Charge and Residual Gases on Thermionic Currents in High Vacuum.
Evaporation, Condensation and Reflection of Gas Molecules.
Fundamental Phenomena in Electron Tubes Having Tungsten Cathodes.
Isomorphism, Isosterism and Covalence.
Mechanism of the Surface Phenomena of Flotation.
Octet Theory of Valence and Its Applications With Special Reference to the Organic Nitrogen Compounds.
Properties of the Electron as Derived From the Chemical Properties of the Elements.
Structure of the Helium Atom.
The Structure of the Hydrogen Molecule and the Hydrogen Ion.

Dr. Whitney is a trustee of the Albany Medical College and of Union College, and a member of the Cor-

poration of Massachusetts Institute of Technology. He is a member of the U. S. Naval Consulting Board, National Research Council, American Chemical Society (president in 1910), American Electrochemical Society (president in 1911), American Institute of Mining and Metallurgical Engineers, American Institute of Electrical Engineers, American Association for the Advancement of Science, American Academy of Arts and Sciences, American Physical Society and British Institute of Metals. He received the Willard Gibbs Medal in 1916 and the Chandler Medal in 1920.

PUBLICATIONS

Dr. Whitney's translation of Le Blanc's textbook of electrochemistry is well known. Among the papers which he has personally published, are the following:

1. The Rate of Solution of Solid Substances in Their Own Solutions (with A. A. Noyes). *J. Am. Chem. Soc.*, vol. 19, pp. 930-34 ('97).
2. The Nature of the Change From Violet to Green in Solutions of Chromium Salts. *J. Am. Chem. Soc.*, vol. 21, pp. 1075-84 ('99).
3. The Precipitation of Colloids by Electrolytes (with J. E. Ober). *J. Am. Chem. Soc.*, vol. 23, pp. 842-63 ('01).
4. An Investigation of Ammonio-Silver Compounds in Solution (with A. C. Melcher). *J. Am. Chem. Soc.*, vol. 25, pp. 69-83 ('03).
5. The Corrosion of Iron. *J. Am. Chem. Soc.*, vol. 25, pp. 394-406 ('03).
6. Electrolysis of Water. *J. Phys. Chem.*, vol. 7, pp. 190-93 ('03).
7. The Migration of Colloids (with J. C. Blake). *J. Am. Chem. Soc.*, vol. 26, pp. 1339-87 ('04).
8. Colloids. *Trans.*, Am. Electrochem. Soc., vol. 7, pp. 225-36 ('05).
9. Arcs. *Trans.*, Am. Electrochem. Soc., vol. 7, pp. 291-9 ('05).
10. Suspensions in Dilute Alkaline Solutions (with Alonzo Straw). *J. Am. Chem. Soc.*, vol. 29, pp. 325-29 ('07).
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12. Some Chemistry of Light. *J. Am. Chem Soc.*, vol. 32, pp. 147-59 ('10); Presidential Address, American Chemical Society, Dec. 29, 1909.
13. Alloys. Amer. Foundrymen's Assoc., 1910.
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19. Electrical Conduction. *Trans.*, Am. Electrochem. Soc., vol. 21, pp. 19-26 ('12); Presidential Address, Am. Electrochemical Society, April 19, 1912.
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CONFERRING THE MEDAL

Willis R. Whitney, Bachelor of Science and Doctor of Philosophy:

It gives me the greatest pleasure, as the representative of the Affiliated Chemical and Electrochemical Societies of America, to place in your hands this beautiful Perkin Medal, as a token of the appreciation and affection of your fellow chemists.

The Biggest Things in Chemistry

BY W. R. WHITNEY

If I were to try to justify my receiving the Perkin Medal I think I would begin by assuming that now good intentions are being rewarded. As the aim of the award is to promote or stimulate research, I must find the ways by which I can most directly do so, and so I ought to say something about the biggest things in chemistry. No matter how irrelevant some of my remarks may seem, I hope you will believe that they are aimed with that high intent. While it is a great honor, it is also a wonderful opportunity to write something which may be read by 15,000 or more American chemists.

In America patents are granted to individuals for their new disclosures. Such patents are not granted to organizations, to companies, nor even to laboratories. This is really an antique limitation, for discoveries are often the result of combined efforts. And so I look at the Perkin Medal, in my case, as an award directed to me, but belonging to the Research Laboratory to which I belong, it having not yet become customary to award such medals to laboratories. In any case, I heartily thank the various men and organizations which made this medal possible, and the committee of award who have chosen that my name shall stand on that honor list headed by Perkin.

I am not going to tell of the specific researches in which I may have co-operated, nor of the good fellows who have carried them out in our laboratory, though

I should like to do so. One reason is that this is, to a considerable extent, being done all the time, through our laboratory system. We have always followed the plan of individual publication as completely as seemed desirable from the scientific point of view and as rapidly as consistent with fair commercial conditions. Moreover, I, being almost the only man in our laboratory who does not often personally carry through separate researches, have already summarized the work of others until it is overdone.

What I have to say oscillates about a central point. This point I see so well that I am surprised that every one does not see it too, and make more use of it. I am also at a loss to know why so many men go through college keeping their eyes mainly on a ball of some kind or other when the world is so full of greater interest. Perkin's life contains all the data which we need in analyzing scientific research, and shows at once what I will repeat throughout this paper—that our great advances are usually made by men who are trained in their particular line of work and are working diligently just beyond the boundaries of the known.

Perkin was a student of chemistry in one of the best college laboratories in England, under a great teacher (Hofmann), who was so imbued with the chemical research spirit that he tried to keep Perkin from stopping to develop technically his discovery of mauve. He actually left such an impression on this young man's mind that after years of commercial success Perkin returned to pure scientific research and enjoyed it for the rest of his life.

The essentials appear to be: First, the teacher, enthusiastic pioneer, hunting and fishing along that ever-expanding outer rim of knowledge; then the laboratory and equipment, supported by some far-sighted government, individual or organization. And then the schoolboy with shining morning face. Don't say it can't be done, and that Perkins, Faradays and Pasteurs are born, not made, for the process is entirely standardized. We in our schools have not realized the proper sequence, because we have used so much of our energy in bringing large numbers of men part of the way only.

On receiving the first Perkin Medal at the time of the Jubilee Celebration Sir William Perkin said that he had all his life insisted on the importance of research and that this medal would accomplish a valuable result if it helped to encourage and stimulate activity in that direction. He then proceeded to tell the interesting story of his own discoveries. Such a story is the strongest force he could have used to support his wish to promote research, and it is true that, although it would have been more agreeable to him if some one else could have told the story, everyone who heard it and the countless chemists who live to read it are glad no one else told it.

Early Interest in Chemistry

No greater satisfaction in connection with my own life's work could come to me than to contribute to the encouragement and stimulation of research. If I can help it to an appreciable extent by telling any unpublished portions of my own story I will willingly disregard for a few moments a natural reluctance to talk about myself.

I learned that Prof. Perkin became a chemist through the influence of an Englishman named Hall, with whom he came into contact when under fifteen years of age, and, moreover, an event which increased his desire to become a chemist was seeing an experiment showing the growth of certain crystals. I have the honor to have started as a chemist in this identical manner, and I will tell a little more about it, because I have always wished I had some way of expressing my gratitude to my particular Mr. Hall.

When I was about fifteen years old an English mill owner and one of the leading citizens of my home town, William C. J. Hall, assisted in establishing a Young Men's Christian Association. He had also long been interested in the microscope and was a scientist such as we seldom find among business men today. He formed a free evening class for about half a dozen boys—all that could work together around the rotating table on which he placed his immense microscope. This was so arranged that specimen, instrument and illuminating system did not have to be disturbed as they passed from one boy to another for observation. He did not merely show his specimens, of which he had thousands, but taught us how to prepare them in all the various ways now more or less common. They were all wonderful to me, and still are.

My mother gave me some money which, combined with that of one of the other boys, purchased a small microtome, and my father gave me $75 for a microscope. Under Mr. Hall's guidance I bought the instrument, with the understanding that whenever I wanted a better one the old one would be taken back at the original price. I later procured one for $250 which, throughout thirty-five years, I have used almost daily. One of the first experiments I tried with the microscope was to precipitate metallic silver from silver nitrate solution onto a speck of copper filings. Anyone who has watched these beautiful crystals grow knows that they are surpassingly wonderful. They constituted my first chemistry. It was those little bottles of salts and bugs in alcohol that led someone to call me a chemist, and it apparently determined my future work.

It does not seem now as though anyone else ever enjoyed a tenth of the pleasures my old microscope introduced to me. I find them inseparably interwoven with about everything I know. Even the barren North Pole reminds me of Andrée and Amundsen and microscopic algæ which drifted across the polar circle from the Lena delta. The equally barren Sahara reminds me of Darwin and De Vries and the diatomes which were carried by the wind from central Africa and fell on the deck of the Beagle, hundreds of miles away.

Concentrating on the Ideal

In trying to put the truthful personal and human element into these notes, as previous Perkin medalists have done for the help of would-be research men, I find I cannot lay valid claim to the insurmountable difficulties nor to especially commendable early struggles which have helped so many others. Perhaps even this admission, however, may have its place for the encouragement of some research man. I was early taught that a dollar a day was a fair wage and that frequently was unearned, and I quit worrying about pay so long ago that the date is not important. I once asked the president of a large technical school for a salary increase of $75 a year and was shown that it could not be done. Perhaps that wise president convinced me that financial rewards are not the main thing. At any rate I believe it.

In mapping milestones not mentioned before I want to express my indebtedness to Prof. A. A. Noyes, who showed me some of the interesting things in the science of chemistry. He let me work with him on some

physicochemical researches, and this work was responsible for my later spending two years with Ostwald in Leipzig and a summer with Friedel in Paris. Work with these men gave me a feeling of surety in chemistry that no mere talk could ever have done. I ought to say that one of our first joint researches, so far as publication was concerned, had the peculiar effect of freeing me forever from the wiles of college football, and if that is a defect make the most of it! Dr. Noyes and I conceived an idea on sodium aluminate solutions on the morning of the day of a Princeton-Harvard game (as I recall it) that we had planned to attend. It looked as though a few days' work on freezing point determinations and electrical conductivities would answer the question. We could not wait, so we gave up the game and stayed in the laboratory. Our experiments were successful. I think that this was the last game I have ever cared about seeing. I mention this as a warning, because this immunity might attack anyone. I find that I still complainingly wonder at the present position of football in American education.

The Bigger Things

I would prefer now to talk about the biggest things in chemistry, not so that I may be facetious, nor yet to form a companion piece to a talk on the littlest things. Far from it. In fact, so far from it that after having some of my thoughts in preliminary notes for years, with a conviction that they ought to be expressed, I have always deferred it. I feared that I was not just the man to say it.

We are all interested in the detailed and specific advances which constitute our science. We know that it is from these little things that the largest ones grow. We see a certain similarity between the history of Prof. Perkin's mauve, with its subsequent enormous development of the dye, medicine and explosive industries, and the development of the living acorn into the spreading oak tree. But we should sometimes look at the forests from the plains, without obstructions. And we want to know our chemistry, too, in its relation to the general landscape. Some kind of an inner man advises us not to think exclusively of the littlest things, the parts of some whole, but sometimes to give constructive thought to the ultimate objects, to our aims at large, our chief pretensions, our real ambitions, our main direction of motion. Are these consistent with or independent of our temporary and apparently vacillating movements?

I know from experiment (as we usually say) that no two chemists would agree at first as to what constitute the most important things of chemistry. I have found, however, that if we say that the "possibilities" are the biggest things, then today there is some agreement among experts.

Tested Laws

Chemistry is one of those branches of human knowledge which has built itself upon methods and instruments by which truth can presumably be determined. It has survived and grown because all its precepts and principles can be retested at any time and anywhere. So long as it remained the mysterious alchemy by which a few devotees, by devious and dubious means, presumed to change baser metals into gold it did not flourish, but when it dealt with the fact that 56 g. of fine iron, when heated with 32 g. of flowers of sulphur, generated extra heat and gave exactly 88 g. of an entirely new substance, then additional steps could be taken by anyone. Scientific research in chemistry, since the birth of the balance and the thermometer, has been a steady growth of test and observation. It has disclosed a finite number of elementary reagents composing an infinite universe, and it is devoted to their inter-reaction for the benefit of mankind. The rate of this advance in chemistry is in our day almost incredibly great.

The History Path

Mark Twain's little history game has given me a view of our rate of development, and particularly of modern as compared with ancient affairs, that I want to pass along to you. Possibly some of you have thought of the rate of mental development, of material development and of power developments as involving only a fairly uniform change through all time. This is not so at all. But to shorten this story: I started from a certain point in the woods with a measuring tape and marking tools and laid out a winding path 1,000 ft. long. I cut smooth marking places on all trees along the way and on some large rocks. I appropriated 1 ft. length of this path for each year's history since William the Conqueror (the year 1000), and spent the rest of my time properly locating prominent events along the path, down to 1,920 ft.

I was impressed by the 45-ft. length of Queen Elizabeth's reign, near the middle of the way, and such a short distance from Columbus and the discovery of America. Stockings and pins and sugar (except as medicine) came into the path about there. But of interest to us particularly is that all the great chemists began to arrive together near the 1,850-ft. point. This seemed very recent. It meant that most of the superstitions about matter began to disappear only about 250 ft. back, so to speak. You all know the story, but for 75 or 80 per cent of my measured path, and for the interminable portion representing all time prior to 1000 A.D. (which I let wind without construction or destruction back the mile or more which might still have been historically illustrated), there had been no need for more than four supposed elements, earth, air, fire and water. It was not the old facts but the dimensions which impressed me. While a foot is ample space in which to erect monuments to everything we know about any year chosen in the fifteenth century, and a single tree could be signpost for all the cards on events for any century a little earlier, there was great lack of space for descriptive matter beyond the 1,800-ft. point.

All down the line, to within a stone's throw of the end, individual man-power had been the important energy, and then as power it almost disappeared. Within 200 ft. of the end, which stood for the present day, steam had been put to use, and there came in turn the myriads of machines which multiplied a thousand-fold the previous constant and limited muscular power of man. No one can accurately determine the added spread of effort due to this substitution of coal for human strength, and then of machines, one for another.

Within 30 ft. of the end of the path a score of new chemistries had grown into activity, and every single one seems more promising than the original stem: physical, colloidal, subatomic, radio, metabolic, biologic, enzymic, piezo, therapeutic—all growing infants. Thus the time seems almost near when, to quote Carnegie, "the mind, like the body, can be moved from the shade into the sunshine."

This interesting game of Mark Twain's actually

chokes itself off mechanically when one tries to post modern chemical work at one foot per year. New facts now take about that space when posted edgewise in abstract journals, a dozen items per page. What this game, applied to chemistry, had done for me is to show me the almost inconceivably great strides in countless lines which constitute our modern chemistry, and it leaves me with the feeling that no one in the world has ever had such possibilities open to him as the present-day student of chemistry.

Creative Chemists

Perkin was a well-prepared research chemist when he made his discoveries. He was just the kind of man of which we produce too few. Only a very small number of our students get so far in the science as he went under Prof. Hofmann, and nowadays, in order to go so far, one must go much farther, for, as Wendell Phillips said, "to be as good as our fathers were, we must be a good deal better." The process Perkin followed is the same one which has led to most of our discoveries. It is the encouragement of natural inquisitiveness under the best conditions. It is using the newest knowledge and best tools in exacting pieces of work. No short-cut and easy process would have produced dyes from tar. Such efforts could not even find a way to make tar acceptable for road material.

One of the biggest things in chemistry for us today is to learn how to bring about the productive teaching of chemistry. The desirable qualities are illustrated by the life of Wöhler, who prepared the first organic compound when the consensus of opinion (and infinite argument) favored the theory that organic compounds were only producible through a mysterious vital force. Pasteur's work is another case of a trained research chemist, and every American should learn his ways. What such explorers seek are not imaginary points on a drifting field of perpetual ice in an uninhabitable world, but something which may possibly help every individual who lives after them.

We might have similar results developing in chemistry today, but they call for the good teachers and the highly trained observer, with well-backed faith. These two, high training and faith, are an uncommon pair with us. They seldom grow within the same Yankee.

Expansion of Inorganic Development Work

I need not repeat what is known about the many disclosures of inorganic chemistry. How, within the past few years, chemical science has at least doubled the number of available metals, and so raised to the *n*th power the possible alloys. All these new metals are generally coming into use, as you know.

I am often reminded of metallic calcium in this connection, because it is really still being born, but the process is the old one. It was produced by high-grade electrochemical research, and the discoverer in describing the process said: "We do not know now of any use for this new metal, but when its properties and production are understood it will probably find its place."

It is almost useless to think otherwise. Here is a chemical element the compounds of which are as numerous and whose ores are as rich as those of any element known. The isolation of the metal is not so simple as in the case of zinc, copper, iron or tin, and its properties are different, but, as usual, it is differing properties which determine the new use. It is worth telling in passing that during the war we made this metallic calcium and found two widely different uses for it. One was as a suitable generator of hydrogen to maintain very high pressure of this gas inside certain deep-sea sound-detecting devices, where the sea water itself was the other reagent. The reaction was slow and well suited for this work. The other use is as a continuously reacting purifier for argon in the tungar rectifier. This latter is now the basis of a considerable manufacturing business. It is interesting, from the chemical research standpoint, because it consists of a bulb made of a special new glass, a tungsten wire spiral, an artificial graphite electrode, a little argon gas and some metallic calcium. Within the spread of my brief experience there was a time when any part of this combination would have been an impossibility from lack of every one of these chemical materials. And so I note such researches as Prof. Lehner's on selenium oxychloride, and I say to myself, "Watch it grow." To add such a liquid to our little category will prove an ever growing utility.

We ask ourselves, Can there be greater fields of new organic chemical research than that which met Perkin as a student? Is not tar the last big raw material? The answer is simple. New fields are greater in number because the territory of chemical knowledge is so greatly broadened and the new tools are so numerous. The results will depend solely on mentality—not tar. Is it not within reason that another as great a field as dyestuffs will be developed directly from carbon itself, for example? The entering gates to organic chemistry, reached by the shortest road, were apparently opened when calcium carbide was first made. Thus, starting with two of our most abundant mineral products, coal and limestone, and adding water alone, we are supplied with the endothermic gas, acetylene. From this point almost anything organic seems possible. When we realize that the manufacture of acetone, alcohol, etc., has been thus made possible from these inorganic raw materials we might as well expect, by the same road, useful food as certainly as medicaments.

I am repeatedly pointing to need in our country for the highest class of chemical preparation. It is not enough to talk of the importance of fuel, of the conservation of coal, of the possible use of benzene or alcohol in our motors. Such have already become problems, and we have a hundred thousand engineers in the country capable of solving them. Some of these men have already carried out the manufacture and use of hexahydrabenzene in motors, for example, but the chemistry itself, as a science, though still infinitely promising, is relatively neglected.

Experiments in Agriculture

Possibly one of the biggest things in chemistry lies in agriculture, but it would be futile for me to treat of its research by the modern truthful but standardized method. It is admitted that we need more and better fertilizers. We now use nearly $200,000,000 worth annually. It is true that we have recently spent many million dollars on nitrate plants. We also think we need half a million tons of potash annually, and of this we can see how to produce locally only about 10 per cent. We want synthetic ammonia and we can get it, because during the war we were forced to adopt production methods derived from foreign chemical research.

I do not need to go farther with agriculture in order to prove that I am not a real farmer, but I insist on doing so because I want to make clear the thought that possibly our troubles in general with Nature are some-

times due to our personal limitations, not to the limitations of Nature.

It looks to me as though possibly man had developed most of the cultivated fruits of the field along the line of maximum human exertion and immunized them to everything else. I draw this hasty conclusion from a single experiment of my own. Last year I procured some special high-grade seed corn and treated portions of it in widely different ways. In one case the kernels were planted, properly spaced, through holes in large sheets of paper placed on new ground which had had its grass killed by a year's covering with gravel, which was then removed. The paper was to discourage the weeds and make hoeing unnecessary. Other hills were planted without the paper, and still others in which the soil was taken up, softened and replaced. None of these new-type gardens was disturbed during the summer. Less radical experiments, including nothing at all but muscular effort, were tried on other hills in an old type garden.

Knowing how corn had been produced through thousands of years of applied work, the results could have been foreseen. All that grown on new soil, protected by paper from weeds and from evaporating winds, took the whole summer to grow about a foot high. It looked very mature, but didn't bother to produce any ears. That which had been about buried in modern artificial fertilizer, and well hoed, pulled through somehow, and that which had been manured and most energetically hoed did the best and gave a normal corn crop.

The growing of corn and grain is an older process than making wire nails and cannot be so easily improved. It has developed with no fair regard to human labor, and will take more novelty of effort to change it than was employed in freeing manual labor from nail, screw and bolt making, or from the production of artificial indigo or synthetic camphor.

When one reads of the experiments of Loeb on the rate of growth of bryophyllum shoots as influenced by various schemes of cutting leaf from stem, etc., one can hardly doubt that new truth, learned for itself alone, in some such way, may at least rearrange some parts of future agricultural research. Anyone who has annually tried to kill a burdock by any means short of complete eradication, or who has watched the persistency with which a lot of wild chicory will grow to maturity in the almost imaginary crack between a reinforced concrete road bed and the adjoining separate curbstone, will appreciate the thought that some time, somehow, man may successfully direct his researches toward the growth of useful vegetation with reduced, not increased, human labor.

Medical Research

Many biggest things in chemistry are coming from chemical research in the field of life and health. When I recall the Rockefeller Institute for Medical Research and think of the international character of its men and work I incline to the belief that through such researches in chemistry and allied sciences the countries of our world may be more certainly finally allied than by the system of countless peaceful words coupled with increasing armaments. There I have seen Carrel, French scientist of the purest type, keeping chicken tissues growing on microscope slides for nearly a decade in order that he may carry out those quantitative experiments which lead to exact medical science. In such an institution a class of refined and exhaustive research work can be done whose results stand as foundation stones on which doctors and surgeons of all lands may build at once. The diplomacy of such institutions leaves no room for international spies. The results, as soon as verified, are published to all quarters of the globe. Jacques Loeb, studying the amphoteric properties of gelatine or the temperature coefficient of the life-reactions of fruit flies, is putting permanent points of observation on the graph of human knowledge where all may see, confirm and use them. The little Japanese Noguchi, a most attractive enthusiast and a co-worker of Dr. Flexner's for nearly twenty years, is now all wrapped up in yellow fever work. He has isolated the germ and prepared the preventive vaccine and the immunizing sera. Thus he adds some of the finishing touches to that story of a fight which has been under way since 1900, when Dr. Lazear knowingly risked and lost his life by letting a certain mosquito bite him.

Wonders of the Brain

If we think of the brain as the workshop of the mind, and then look back over the history of the growth of brains, we find that this workshop first appeared as a relatively *very* small portion of the mass of the early animals. All the prodigious vertebrates of the mesozoic period had exceedingly small brains in proportion to their bodies. The brain size in comparison to the size of the animal has always been on the increase. In man and his forerunners this is also well known. But it is significant that even with man there is no continuing brain growth when he is kept from doing or thinking something new. The Egyptian fellaheen, who were kept at unchanging labor for many centuries, possessed the same size brain cavity at the end as at the beginning of that period. But the diameters of the brain cavities of the early man-forms after the chimpanzee (the Trinil, Piltdown and Neanderthal men) stand to man as at present in about the relation of the numbers 12, 13, 14 and 15.

And yet, in this most modern workshop, the energy which is consumed is so small, when compared to the work done by other organs of the body, that it cannot be measured as energy at all. It is easy to measure the work done by the little finger and express it in calories consumed from the food eaten. The most extensive mental exercise is much more economical of energy. In other words, we have not yet taxed the mind's workshop from the energy or work point of view. All this means that, following the direction of natural development, there need be no lack of that brain power or mentality which is needed to handle all that we may wish to know and think.

Mentality

The biggest thing of all in research is the mental effect, the projecting of a beam of light into the infinite and the growth of man's appreciation. I can scarcely touch the many connections here. But in delicacy and sensitiveness the mind far transcends the wireless receivers which yet read, half around the world, a message sent by a few watts of energy. And I need say nothing about its possibilities as a power producer or controller. In co-operative work minds multiply, instead of adding together, and growth of mind depends on the experiments or the reactions with things. Whether mind is polarized energy, or merely a long habit, may still be in doubt, but there can be little doubt as to what expands it.

Not very long ago it was safer to conceal new truths

than to disclose them. If a man wished to die by some horribly ingenious method he had but to discover something like the rotundity or mobility of the earth and insist on it. For advocating justification by faith alone he would be burned alive. Dabbling with intangible matters which led only to disputation was gradually displaced by increased attention to immediate surroundings.

Is it too much to say that through research into materials the main advances in physical and mental welfare take place? Where do we meet contradiction if we say that, except for research or experimental study of matter, we stand still or mill about in circles filled with superstitions? Particular attributes of the human mind may well have reached higher altitudes in some previous age, as is usually claimed. In specific lines of human undertaking we can but accept this as true. We have no Homer among our poets, no Cellini nor Angelo nor Da Vinci among our artists. Plato and Aristotle and many others ages ago equaled our present-day logicians. Such are the nuggets of truth which the seeker for values in history is apt to dig up. As architects or sculptors or hewers of stone we may be retrogressing, and in any selected development we may have passed zeniths, but all the time the knowledge of the universe and of each atom of it, from the tiny flower of the crannied wall to the sun which brings it forth and the stars which so immensely exceed this, has been rapidly increasing. The only perpetual motion is the growth of truth. Possibly faith, hope and love are not at a maximum in our age, but they may be, and through all ages there seems to run Tennyson's one "increasing purpose." Only one sure line of continuing increments can be traced. It is not the line of the search for waters of eternal youth. It is not the series of philosopher-stone experiments, though a few of them contributed to the steady growth of our horizon. It is not the line of ascetism, stoicism, religious tolerance or intolerance of any form, nor yet the political systems of the widest variety. They are now useless except as they added to the accumulating mass of truth. Appreciation of environment has always increased.

Religion

The natural desire for religious truth has been responsible for most colleges and universities. They served first to encourage learning and prepare religious teachers, but only recently has it become the recognized duty of universities to seek truth by investigation of material things. Goldwin Smith wrote of Oxford in the early days that, "For the real university students the dominant study was that of the school of philosophy, logical and philosophical, with its strange jargon; an immense attempt to extract knowledge from consciousness by syllogistic reasoning instead of gathering it from observation, experience, and research, mocking by its barrenness of fruit the faith of the enthusiastic student. The great instrument of high education was disputation often repeated, and conducted with the most elaborate forms in the tournament of the schools, which might beget readiness of wit and promptness of elocution, but could hardly beget habits of calm investigation or paramount love of truth."

The uptrending curve of recognized facts might be called Nature's appreciation curve, or the growth of mind. While cattle eat, drink and die with no more appreciative attitude toward their surroundings than shown in previous ages, mankind has accumulated, by experiment, everything that distinguishes him. But certainly the end of this growth is far away and still out of sight. When men can talk so glibly about their closeness to a Creator and yet uniformly show, by destructive warfare, their extreme remoteness, surely the great undertaking, whatever it means, is not nearly complete. We have much to learn.

May it not be possible that the human urge for new truth, the world trend for clearness of vision in material things, will be justified? Can there be a better way of appreciating the wonders of creation than by looking into them, uncovering, understanding and appreciating them?

I should identify all search for scientific truth with the highest religious aim, no matter what the cult. I would point out here that our inactivity and inappreciation in the presence of infinite, undeveloped truth is the most inexcusable type of error and unfaithfulness. It is intense faithlessness, no matter what conception of a Creator we adopt.

There is no better (perhaps no other) way of going forward in the new paths which instinctively attract us than by using new material knowledge. Is it not possible that words of affection, of sympathy and promise of all kinds, helpful, heartfelt and beautiful as they may be, are only the paper money of our transactions, and that behind them there should be gold of service in which to pay the promises?

I do not look at this as crass materialism. We all know that the mere chemical reactions of the brain are not the whole story. A measuring machine repeating automatically all the motions of the scientist would not interest us at all. Appreciation of the infinite is not mechanical, but truth is necessary for appreciation. John Burroughs has said: "Every day is a Sabbath day to me. All pure water is Holy Water, and *this* earth is a celestial abode. It has not entered into the mind of any man to see and feel the wonders and mysteries and the heavenly character of this world." Yet most of what even John Burroughs sees and appreciates is outside of the infinitely beautiful and orderly realms of modern chemistry. When we are first old enough to ask ourselves questions we are so mature that we seem already surrounded by an infinitely complex and interesting environment. A persistent and age-old instinct makes us want to wander

> "Into regions yet untrod
> And read what is still unread
> In the manuscripts of God."

And it has developed that in no other way may we hope to understand and appreciate. Chemists should naturally be the first and greatest appreciators. Research is appreciation.

Efficiency of Electroplating Greatly Increased

Much interest has been aroused by the account given at a joint meeting of the Faraday Society and the Institute of Metals held in Sheffield of a discovery made in the university of that city which will increase the output of electroplating factories by 100 per cent. Frank Mason, the inventor, who is lecturer in electrometallurgy and electrochemistry in the university, discovered by experiment that by a change in the chemical composition of the electrolyte the maximum current of the bath could be increased by over 100 per cent and the process of electroplating performed in less than half the time taken by the existing method.—*The Engineer*, Nov. 26, 1920.

Swedish Electric Pig Iron Furnace

Brief Description of the Constructional Details, Methods of Starting and Operation—Gray Iron, Low in Sulphur, May Be Had by High Power Input—Operating Figures for Long Campaign in 1920—Estimate of Cost

By JONAS HERLENIUS
Secretary-Treasurer Hamilton & Hansell, Inc.

FOR various reasons the question of electric iron ore reduction has lately been of vital interest, not only in this country but throughout the world. The increased price of coke and consequently pig iron, the higher cost of transportation and the present ample development of cheap hydro-electric power in vast territories where suitable ores and charcoal are available for the production of a higher grade of pig iron, are probably the main reasons why this question has been brought into the limelight. Another fact, which may also have an important bearing on the subject, is that a certain type of furnace for this purpose has been successfully used in Sweden, although very little information regarding operating results and performances is available to anyone desiring to make a study of the situation. It is the object of this article to describe the Swedish electric pig iron furnace and to summarize briefly some of the results from its use as a commercial unit for iron ore reduction.

Development

In 1909 the first Swedish electric pig iron furnace was installed in Domnarvet, Sweden. It was in operation for about three months, but afterward was shut down for a long period. On the basis of the results obtained, however, a special trial plant was built in 1910 at Trollhättan, Sweden, by "Jernkontoret" (the Swedish Iron and Steel Institute), on a government appropriation in order to develop an electric-furnace type that would satisfactorily replace the ordinary charcoal blast furnace. The trials were conducted with skill and accuracy by expert engineers for nearly two years and the results obtained proved to be very satisfactory, both from a practical and economical standpoint. Several of these furnaces have since been installed in various steel plants in Sweden, so that at the present time a total of twelve units are in operation in that country, ranging in size from 2,200 to 8,000 kva. transformer capacity. In addition, there are also similar furnaces in operation or contracted for in Norway, Italy, Japan and Brazil.

Description of Furnace

The furnaces are installed in buildings of brick, concrete or steel construction containing the entire furnace and its surrounding pig beds and provided with spacious charging floors. The furnace proper consists of a wide melting chamber or crucible, above which is a shaft with a bell-charging apparatus at the top. Fig. 1 is a section of a typical modern furnace; the dimensions are special for each installation and have to be calculated for the capacity, the kind of ore, the charcoal or coke available and the grade of pig iron to be produced. The shaft is thus designed in accordance with the general practice for common blast furnaces, except for a recent tendency to widen out the lower section, making the diameter of the shaft at its junction with the crucible even larger than at the bosh.

The entire brickwork and shell plate of the shaft are suspended independently of the crucible. A steel ring is attached to the shell plate and rests on brackets and cross-girders supported by three or four columns, either a part of the furnace building or preferably independent of it. The bottom of the shaft is an iron ring, which makes a flexible joint with a corresponding watercooled ring serving as a skewback for the bricks in the crucible roof. The shell has an extension of from 6 to 9 ft. above the stockline and carries the charging bell. In this extension openings are made for the gas outlets.

The crucible is cylindrical and is contained in a mild steel shell resting on beams supported by a concrete foundation. The electrodes are inserted through the thin brick roof at an angle of about 65 deg. to the horizontal.

The entire shaft is lined with firebrick and the thickness of the wall is about 18 in. for the upper and middle sections and about 14 in. for the lower. The crucible is also usually lined with firebrick, although lately rammed-in coke or waste electrodes have been used with good success both in the bottom and in the sidewalls. The roof is lined with special shaped firebrick. To prevent it from raising, on account of the gas pressure within the crucible, an outside latticed steel construction suitably braced and connected to the shell plates is provided.

Gas Circulation

The waste gases from the furnace are taken through either one or two openings in the throat. They are carried in gas conduits of sheet iron, with internal water sprinkling, to a large dust catcher, and from there to suitable washers and scrubbers for cleaning and cooling. The gas is drawn from the furnace through these apparatus by an exhauster having a capacity of 1,700 to 2,800 cu.ft. per minute at 14-in. water gage. This exhauster is direct connected to a 20- to 30-hp. totally inclosed variable speed motor. It is specially constructed to deal with the gas and has internal water-spraying appliances. A duplicate set is always installed in parallel for emergency, and one of them is periodically shut down for cleaning.

A portion of the gas is returned to the furnace by means of either one of the above-described exhausters, or in order to assure a constant supply, by a separate rotary blower of the same capacity, but operating under a pressure of about 20-in. water gage. This gas is forced into the free space between the charge and the roof of the crucible, through a number of tuyeres in the wall. They are supplied from a bustle pipe and point upward to blow the gas directly underneath the roof in

order to cool it. There is consequently a certain quantity of gas circulating through the furnace, which is beneficial for the preheating of the charge in the shaft and for facilitating the preliminary reduction of the ores. The volume of this circulating gas is constant and the gas formed during the process is, therefore, available for heating auxiliary boilers or furnaces in the plant. For this purpose it is of particular importance on account of its high B.t.u. value.

Electrodes

The electrodes used are almost exclusively made of amorphous carbon and number from four to eight, depending on the capacity of the furnace. They are round, 24 in. in diameter, have nipple joints for continuous

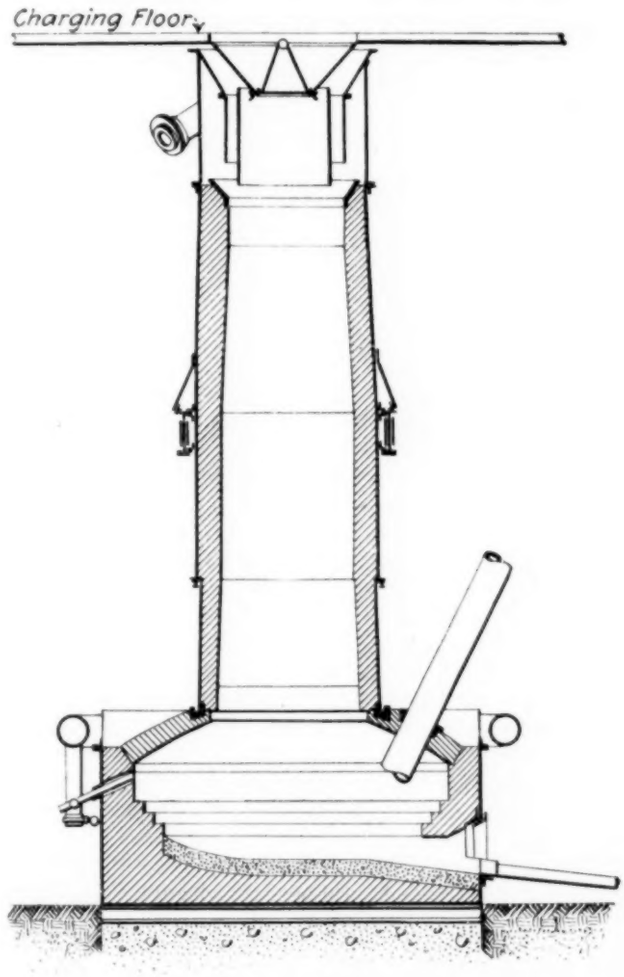


FIG. 1. SECTION OF A TYPICAL SWEDISH ELECTRIC PIG-IRON FURNACE

feed and can be loaded up to about 16,000 amp. Heavy water-cooling boxes and gas glands are placed in the apertures where the electrodes enter the crucible roof and close to them are water-cooled contact clamps of copper directly connected to the busbar work. As the power input is regulated by changing the potential on the transformers, there is no need of electrode adjustment except as they are consumed. The feeding mechanism for that reason is extremely simple and consists only of a screw drive with handwheels. The electrodes are mostly supplied from Sweden or Germany; American makes have been used extensively, the price, however, being at present too high on account of prevailing rate of exchange and the high freight rates. Graphite electrodes have been used successfully, although no figures on their cost are available in comparison with amorphous carbon. There is a possibility, however, that such electrodes will be necessary on account of their high current conductivity in larger furnaces requiring more power and where consequently a higher amperage must be carried.

Cooling System

In addition to the electrode coolers and contact clamps, there are various other parts of this furnace that must be water-cooled. For instance, at the flexible joint between furnace shaft and crucible there is a water-cooled ring. In the shaft brickwork, at the tap hole, tuyeres, etc., there are water pipes and coolers in accordance with standard blast-furnace practice. Furthermore, most furnaces lately installed have a complete water-spraying device for the entire shell of the crucible. In addition water is required for cooling the transformers, exhausters, gas conduits and for cleaning the gas. It is, therefore, of utmost importance that an ample water supply be provided at suitable pressure and that the operation of the system be safeguarded against breakdown. For that reason centrifugal pumps are always installed in duplicate, each having a capacity of about 200 gal. per minute. In addition a tank of about 500 cu.ft. capacity is situated on the charging floor at a higher level than the furnace. This is desirable to provide against any temporary failure of the main supply pipes.

The crucible roof is air-cooled on the outside by means of blast supplied from a small rotary blower connected to a 5-hp. motor.

Handling of Slag and Iron

Usually both cinder and iron notches are provided. For very rich charges, however, only the iron notch is used. The iron is run in launders to the pig beds, as shown in Fig. 2, or may be poured in a ladle for transportation to a mixer or bessemer converter. The slag is collected in large pots and the arrangements for tapping or handling iron and slag do not differ from general blast-furnace practice.

Electrical Equipment

The operating current for this type of furnace may be either two-phase or three-phase, depending upon the furnace capacity. The average size furnace has about a 3,000 to 4,000 kva. transformer bank, consisting of three single-phase transformers which are delta connected on primary. On secondary six independent phases are induced, each connected to one electrode, making a total number of six. Larger furnaces have two single-phase transformers which are Scott-connected for incoming three-phase, giving a two-phase, four-wire system. On secondary each conductor is then connected to two electrodes, making a total number of eight.

The transformers are installed as close to the furnace as possible in order to use a minimum amount of busbar copper and to avoid excessive current loss by induction. The transformers are specially constructed to withstand the heavy duty imposed upon them. The secondary voltage can be regulated in eight to nine steps, from 55 to 110 volts for charcoal, or from 35 to 70 volts for coke furnaces by means of reduced capacity taps on primary coils. The tap changing is accom-

plished under full load for each phase separately by means of eight-way primary selective break switches, remote operated with handwheels from outside the transformer room.

The transformers and the above-mentioned selector break switches, together with other electrical equipment required, such as main automatic oil-circuit breakers, lightning arresters, power transformers, etc., are all installed in a separate transformer room, which usually is an extension to the main furnace building. The secondary busbar leads are brought over from the transformers to the furnace interlaced and are directly connected to the contact clamps.

In order to cut down the cost of copper and the induction losses installations have also been made where one transformer unit is located directly in front of each pair of electrodes. Rotary fans are then necessary for cooling the transformers. This arrangement, however, is not practical from an electrical standpoint especially with respect to primary interconnections.

All instruments necessary for the electrical control of the operation are mounted on panels conveniently situated on a level with the roof of the crucible. The handwheels and handles for operating the primary switches are mounted on panels that fit into the wall of the transformer room.

The incoming primary current on the different Swedish installations varies from 6,800 to 20,000 volts and in each case is stepped down directly to the operating voltage of the furnace. The number of cycles does not seem to have much bearing on the matter, as there are installations on 25- and 50- as well as on 60-cycle current.

Heat Generation

The heat in the furnace is generated by the passage of current between the electrodes and is proportional to the voltage between any pair of electrodes. The power input is regulated by changing the potential on the transformers, and the connections are arranged so that the transformers can operate without injury with different phase voltage. This is an important feature, as the power input is usually regulated according to ammeters or wattmeters which are connected to the secondary busbar leads for each electrode. The operator must endeavor to maintain an even power input for each electrode and must change the potential whenever necessary. As the resistance of the charge between the electrodes changes the potential has to be adjusted to maintain the same power input. Occasionally, however, the power at one electrode may have to be increased or decreased to obtain an even melting or sinking of the charge.

FIG. 2. LOWER PORTION OF FURNACE AND IRON RUNNER

Charging Floor and Handling of Ore

It is of great importance in the operation of this type of furnace as on all charcoal blast furnaces that the charge of ore, lime and charcoal or coke be properly distributed in fixed quantities. For this reason a specially constructed gas-tight bell is used with double conical rings in which the charge is contained. The bell is discharged by means of a hoist by a double movement whereby the content of each ring is emptied separately. The hoist and winding gear for raising and lowering the bell is operated by a 4- to 5-hp. reversible and totally inclosed electric motor.

On one side of the charging floor are installed a number of ore bins provided with discharge gates, and the bell is charged by hand with a charging bucket. The ore bins should have a total capacity of from 70 to 100 tons per furnace. Fig. 3 is a view of the charging floor.

The ore should be crushed down to 2½ in. maximum size and preferably less. For this purpose crushers are installed on the ground level in a special building. Usually one gyratory crusher, driven by a 60-hp. motor, is sufficient, but for larger installations two or three crushers are employed. The crushed ore drops into a loading chute, then into an automatic skip, which discharges into a receiving hopper on the feed floor. From there the ore is distributed to the various bins by means of a larry-car, which can be spotted automatically.

For smaller furnace installations the skip hoist is usually replaced by an inclined bucket elevator, which unloads onto a belt conveyor with a tripper.

Some installations have also been made where the ore bins are located on the ground, in which case the prepared charge is hoisted up in a bucket to the charging floor and tipped into the bell.

Charcoal or Coke Storage

Charcoal or coke should be stored in a special fireproof building of concrete or steel construction, with walls and roof of corrugated iron, having a capacity of about a year's supply. After screening the fuel is loaded into buckets having a capacity of about 30 cu.ft. and transported to the charging floor of the furnace by means of an aërial tramway.

Working Staff

The operation of the electric pig iron furnace requires the same class of labor as common blast furnaces. For an installation of two furnaces the follow-

ing force is necessary: One superintendent, one assistant superintendent, two chemists, three foremen, one electrician, one crane operator, eight common laborers per shift. In addition there will be required two men per shift for loading charcoal and from three to five men per shift for unloading and crushing the ore.

Starting of Furnace

The furnace should be slowly pre-heated with a coke or wood fire in the crucible for about two to three weeks. After the ash is removed and 2 to 3 tons of coke is shoveled into the crucible through the electrodes holes about twenty charges of coke, ore and lime are filled in and the electrodes inserted. Carbon blocks are placed directly underneath each electrode to insure a good contact. The entire shaft is filled with charges of mixed ore, lime, coke and finally charcoal with slowly increasing ore content. The current is then switched on, but the gas circulation is not started until about two days after.

Operating Data

Swedish ores are usually very rich in iron and consist of magnetites and black hematites in the form of lump ore or concentrate, either crude, briquetted or sintered. The various ores available are mixed with suitable fluxes, such as bessemer slag and lime, to obtain the desired slag. In general the charges will contain anywhere from 50 up to 60 per cent of iron. Fine concentrates can be used dry only and to a limited amount, the maximum being about 30 per cent. The reason for this is that they have a tendency to pack in the shaft and stop the circulation of gas, not only on account of their fine character but mainly because they easily flux and seem to attach themselves to the refractories. This may cause scaffolding with subsequent caving of the charge, serious disturbances in the furnace operation very difficult to overcome whenever they appear. (Increasing the gas pressure as a corrective would not be feasible, as the thin brick roof of the crucible would then give way.) The lime should be crushed to the size of a large walnut and usually does not have to be burned. In furnaces operating with coke, however, burning seems to be of some advantage.

Charcoal should preferably be of pine, in lump form and fist size. The fine material after screening can be used only with difficulty and to a very limited extent. Charcoal made of refuse from sawmills is not very suitable, as it contains mostly flat pieces that stop the gas circulation.

A typical analysis of Swedish charcoal is as follows:

H_2O	13.21	Ash	2.18
Gas	11.72	C	72.89

and the average weight is 40 lb. per hectoliter.

The consumption of charcoal is, of course, dependent on the ores and the operation of the furnace, but in general will amount to only 35 to 45 per cent of the requirement in a common blast furnace. It may be of interest to know that during 1918 the average consumption of charcoal in all Swedish blast furnaces was 56.6 hl. per ton, whereas in the electric pig iron furnaces it amounted only to 24.8 hl.

Operation on Coke

In regard to the operation on coke very little data are available, although furnaces are now running in Norway using a mixture of coke and charcoal as reducing agent. Trials made in Trollhättan led to the conclusion that the operation on coke was not satisfactory. This, however, was due to the fact that the furnace and equipment were not suitable for the purpose. Trials made in Tinfos and Hardanger, in Norway, showed that the dimensions of the shaft as well as the crucible had to be changed materially. Coke has a higher current conductivity than charcoal and furthermore tends to graphitize, for which reason the potential must be lower, and suitable taps on the transformers arranged accordingly. It may, therefore, be assumed that a properly designed coke furnace, with equipment provided for the purpose contemplated, may be a success. An interesting report on the results obtained with coke in furnace installations in Norway has been written by George Stig and appeared on page 29, July 7, 1920, issue of Chemical & Metallurgical Engineering.

It has been proved that the pig iron produced from these furnaces is of a higher grade than the iron from common blast furnaces. The reason is probably that

FIG. 3. VIEW OF CHARGING FLOOR

electric pig iron is more thoroughly deoxidized and, therefore, requires less content in Si and Mn to be suitable for the open-hearth process.

The iron and slag from electric pig iron furnaces are always tapped at a lower temperature than from common blast furnaces. This is contrary to what would be expected when using electricity for heating, but is due to the large capacity of the crucible. Directly underneath the electrodes the heat is, of course, intense, but in the center and bottom of the crucible and between the electrodes are fields where heat must be supplied by conduction. The cold gas and the effective cooling of the roof are also features that greatly contribute toward lowering the temperature so that the average will be comparatively low.

With an ample power input, however, the temperature can be considerably increased so that no trouble has been experienced, at least in later installations, in producing a pig iron high in carbon and silicon and with a gray fracture.

The operation of these furnaces is very simple and requires less labor than common blast furnaces, as long as no variations in the charge are made. Any alterations, however, in the amount of ore and coke must be carried out carefully, as the furnace will react very suddenly if the changes are made too violently and disturb the equilibrium in the crucible. It must also be borne in mind that the means to re-establish

normal conditions are very limited for this type of furnace. Usually the only remedy is to throw ore or coal into the crucible through openings in the roof, as a change in the charge would not have any effect until a long time after.

Production of Gray Iron

On account of the intense heat of the arcs from the electrodes a certain amount of calcium carbide is formed, which evidently has a deoxidizing effect on the iron. This carbide slag will also eliminate some of the sulphur, although not to the extent that would be expected. As a matter of fact, the desulphurizing in these furnaces in usual practice is less than in the ordinary blast furnace, which, of course, is due to the lower temperature. However, with high-powered furnaces lately installed, sulphur has been successfully eliminated by an ample power input producing an iron of gray fracture and high silicon. It is, therefore, obvious that the introduction of carbon and silicon and the elimination of sulphur is a matter of using coke, power and time in the furnace, but can always be accomplished. High-sulphur ores, however, should be roasted not only to save power, but to avoid the large charge of lime that otherwise would be necessary and that would make the slag too basic and sluggish.

Most furnaces operate with a slag of about 1.4 to 1.5 silicate degree (a sesquisilicate), which is satisfactory, especially when the bottom is made of crushed coke. Preferably, however, the silicate degree should be lower and down to 1.0 (a singulo-silicate), in order to avoid bad corrosion from a more acid slag.

Furnace Gas

The temperature of the gas extracted from the furnace is, of course, dependent upon the pressure obtained from the blower. On late installations, the temperature is about 400 to 550 deg. F. The dust contained in the gas was investigated in Trollhättan and found to be 4.63 g. per cu.m. gas (of 0 deg. C.) in the down-comers from the furnace shaft. To show the efficiency of the cleaning system, it may be of interest to know that after the washer and scrubber the content was reduced to 0.88 g. and in the bustle pipe to 0.62 g.

An average analysis of the gas from this furnace shows results as follows:

	Volumes Per Cent		Volumes Per Cent
CO_2	23.49	CH_4	1.52
CO	63.15	N	1.49
H	10.35		

The weight of 1 cu.ft. of dry gas was 0.081 lb. and the heat value 2,297 cal. per cu.m., which is equal to 258 B.t.u. per cu.ft. dry gas.

The gas circulation has been greatly improved lately by the installation of positive blowers that deliver a constant volume of gas. This was the key to the solution of a variety of difficulties, especially with respect to uniformity in operation.

Repairs and Renewals

Late figures on electrode consumption are rather high, probably due to their war quality. Previous to the war it required from 11 to 15 lb. per ton of pig produced and the greater part of this consumption is due to the carbon dioxide of the gas being reduced by the incandescent carbon to CO.

In regard to the life of refractories, the weakest point in the furnace is the crucible roof, parts of which must be renewed as they burn out during the course of operation. For a large furnace installation of five units during 1917, the total production of pig iron was 29,255 tons and the total quantity of brick used was 416 tons. For 1918 corresponding figures were 25,791 tons with 391 tons of brick and for 1919, 22,350 tons, consuming 380 tons of refractories.

A complete relining of the crucible roof can be accomplished in about 5 days, using a force of sixteen men, and a complete relining of the entire furnace will take about one month.

An installation of one furnace will utilize about 76 to 77 per cent of the power, whereas for several furnaces the load factor will increase and approximate 80 per cent. The power factor is, of course, dependent on the number of cycles, but will average about 90 per cent for 25-cycle current. The efficiency of the furnace is about 70 to 75 per cent, based on the experience with the Trollhättan installation.

Actual Results

The results obtained from the operation of these furnaces are naturally greatly influenced by local conditions at the various plants, as for instance the number of furnaces installed, the capacity and the power behind each unit, the kind of ore used and the character of the pig iron produced.

In the following table some actual results during the first seven months of 1920 are given from the operation of a large plant of several units, having a transformer capacity each of 3,000 to 4,000 kva.

	Furnace 3	Furnace 5
Total amount of ore used, tons	5,733.20	6,310.41
Total amount of lime used, tons	568.74	742.80
Total amount of ore and lime used, tons	6,301.94	7,053.21
Total amount of charcoal, lb	2,957,440	3,112,640
Total amount of current, kw.-hr	9,576,200	9,001,700
Operating time, hr. and min	3,736 5	2,989 35
Idle time, hr. and min	167 45	97 25
Total time, hr. and min	3,903 50	3,087
Produced pig iron:		
Open-hearth, tons	365,670	3,483.275
Bessemer	3,307,585	.....
Total, tons	3,673.255	3,483.275
Relative figures:		
Electrodes, lb. per ton pig	17.6	19.3
Charcoal, hl. per ton pig	20.1	22.3
Electric current, kw.-hr. per ton pig	2,605	2,580
Average load in kw	2,565	3,020
Pig iron per day in tons	22.5	27.1
Per cent pig of ore charged	64.2	55.25
Per cent pig of total charge	58.3	49.40
Lime in per cent of ore	9.95	11.75
Idle time in per cent of operating time	4.47	3.23

"Ton" means metric ton of 1,000 kg., equal to 2,205 lb. (approximately 1 long ton).

Cost of Installation

The total present cost in the United States of a complete electric pig iron plant with one furnace of 4,000-kva. transformer capacity is estimated at about $150,000.

New York, N. Y.

Fire Destroys the Wilmington Leather Co.'s Plant

The plant of the Federal Leather Co., at Wilmington, Del., was practically destroyed by fire which started in some unknown way in one of the older buildings and quickly spread throughout the entire works. Eleven buildings and valuable stock of both raw materials and finished leather products were destroyed before the fire was got under control.

Steel Castings of High Strength and Toughness—I

A Chapter From a Forthcoming Book Giving Data on the Improvement to Be Expected After Properly Heat-Treating Steel Castings, With Illustrative Tests on Strong, Tough Castings Which Have Replaced Forgings on Gun Mounts

By FEDERICO GIOLITTI
Bessemer Medalist

IT IS useful to illustrate the great variety of results obtainable on various types of steel castings by applying the processes which have previously been studied in theoretical outline,* especially in connection with the differences existing between the effects of homogeneity quenchings and of mere homogeneity annealings. In order not to multiply the examples unduly, some of the more characteristic and, so to speak, typical instances will be chosen.

Normalized Mild Steel Castings

A soft steel casting containing carbon 0.23 per cent, manganese 0.66 per cent, silicon 0.21 per cent, phosphorus 0.05 per cent, and sulphur 0.03 per cent was reheated at 850 to 900 deg. C. and allowed to cool very slowly, requiring about thirty-six hours to reach room temperature.

It showed the microstructure reproduced in Fig. 1 and physical properties shown in Table I determined by pulling a tensile test-piece 12 mm. diameter and 40 mm. long between reference points.

A prismatic test-piece 20 mm. square tested under static flexure broke at an angle of 130 deg. with a coarsely crystalline fracture reproduced in Fig. 4.

The same steel reheated during twelve hours at 800 to 850 deg. C. and left to cool, requiring ten hours to reach atmospheric temperature, showed the microstructure reproduced in Fig. 2 and somewhat better physical properties (Table I).

The tension test revealed a "mixed" structure containing part crystalline and part fibrous texture, as shown in Fig. 4. The static bending piece bent into a U shape.

*"Heat Treatment of Soft and Medium Steels," Press of McGraw-Hill Book Co.

Finally, another casting of the same steel—after undergoing the first treatment above mentioned—was reheated at 800 deg. C. during twenty minutes, quenched in boiling water, and finally drawn during one hour at 650 deg. C. Its properties, especially the ductility, as shown in Table I, are still better.

The microstructure of the steel thus treated is reproduced in Fig. 3. The fracture of the broken test-piece reproduced in Fig. 4 was entirely fibrous.

TABLE I. PHYSICAL PROPERTIES OF HEAT-TREATED 0.23 C STEEL

Heat-Treatment	Tensile Strength	Elastic Limit	Elongation	Reduction in Area
Reheated to 875 deg. C., cooled in 36 hr.	61,600	34,300	13	....
Reheated 12 hr. to 825 deg. C., cooled in 10 hr.	68,000	41,000	17	13.9
Complex (see text)	73,600	47,000	17.5	24.8

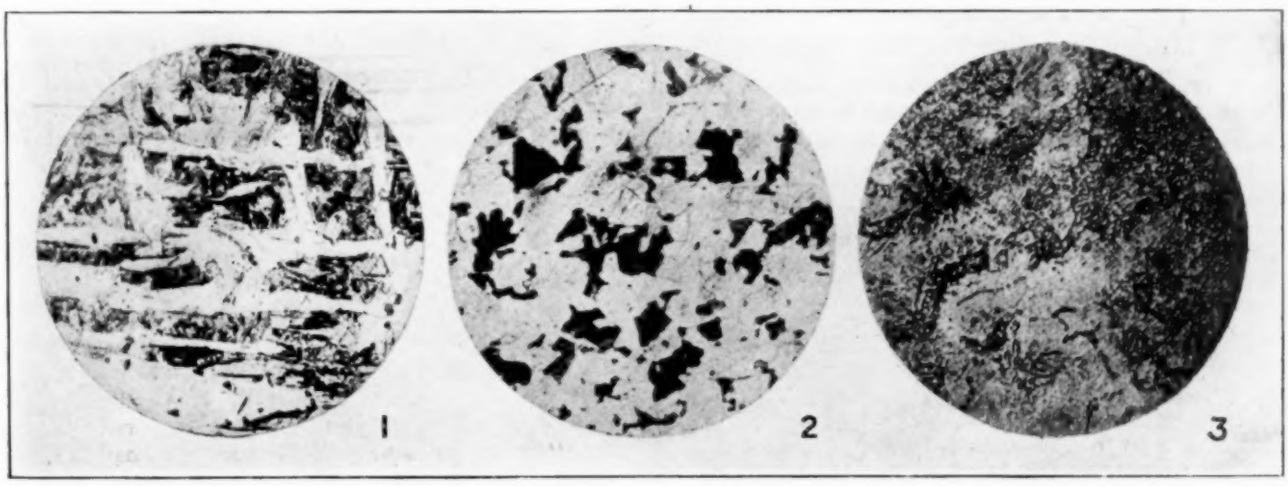
The prismatic flexure test bent into a U, similar to the previous one.

Effect of Insufficient Annealing

Another mild carbon-steel may be cited, made by the acid process and having the following composition:

	Per Cent
Carbon	0.25
Manganese	0.85
Silicon	0.15
Sulphur	0.02
Phosphorus	0.03

It was cast in ingots 15¾ in. (400 mm.) square. Fig. 7 shows the structure of this steel as cast. Rectangular bars 3⅛ x 5⅞ x 11¾ in. (80 x 150 x 300 mm.) were taken from the lower half of those ingots and subjected to the heat-treatments indicated in the first column of Table II. In the next four columns of the same table



FIGS. 1 TO 3
Structure of 0.23 C. steel casting after various heat-treatments.

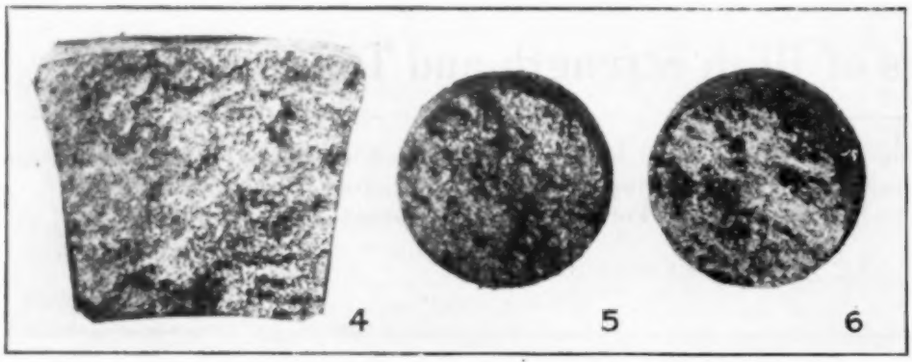


Fig. 4. Fracture in static bending after very slow cooling.

Fig. 5. Tensile fracture after normalizing

Fig. 6. Tensile fracture after complex heat-treatment.

are noted the principal tests on tension pieces 13.8 mm. in diameter by 100 mm. long taken from the bar after being subjected to the heat-treatments indicated in the first column.

TABLE II. TESTS ON 0.25 CARBON CASTING

Heat-Treatment	Physical Properties: Tensile Strength, Lb. per Sq. In.	Elastic Limit, Lb. per Sq. In.	Elongation, per Cent	Reduction in Area, per Cent	Structure (Enlarged 100 Dia.)
Annealed at 940° C. during 45 min. followed by slow cooling in the furnace	79,600	42,700	17.5	18	Fig. 8
Annealed at 850° C. during 45 min. followed by slow cooling in the furnace	76,800	44,200	14	13	Fig. 9
Heated and cooled as No. 1 followed by a drawing at 700° C. during one hour and subsequent slow cooling in the furnace	73,200	39,800	21.5	27	Fig. 10
Heated and cooled as No. 2, followed by a drawing at 700° C. during one hour and subsequent slow cooling in the furnace	74,500	42,700	26	35	Fig. 11

The tabulated data particularly exhibit what has been said relative to new heterogeneities induced by recrystallization of ferrite from a system of austenite crystals in which the greatest part of the original chemical heterogeneities has been undisturbed by insufficient annealing. Inherited non-uniformities are especially evident in the large variations in ductility due to ferrite accumulations accentuated by the drawing operations. To be convinced on this point, compare structure and the figures for elongation and the reduction of area of the first and second test-pieces with the third and fourth.

Limited Effect on Very Soft Castings

In order to confirm the relatively limited effects which homogeneity heat-treatments produce upon the physical properties of very low-carbon cast steels which, by the way, never present the real phenomena of ingotism, I may add in Table III some comparative data between the effects produced upon the physical properties of one of those steels by a pair of homogeneity quenchings of considerable energy. The steel examined was of following composition:

	Per Cent
Carbon	0.09
Silicon	0.028
Manganese	0.47
Sulphur	0.01
Phosphorus	0.02

TABLE III. NORMALIZATION OF 0.09 PER CENT CARBON STEEL

Heat-Treatment	Physical Properties: Tensile Strength, Lb. per Sq. In.	Elastic Limit, Lb. per Sq. In.	Elongation, per Cent	Reduction of Area, per Cent
Heated at 850° C. for 3 hr., followed immediately by quenching in water and then drawn at 650° for 2 hr.	50,500	30,000	31.8	55.8
Heated for 14 hr. at 1100° C. followed immediately by quenching in water. Reheated at 850° C. for 3 hr., followed immediately by quenching in water. Finally, drawn at 650° C. for 2 hr.	54,500	33,700	33	60.2

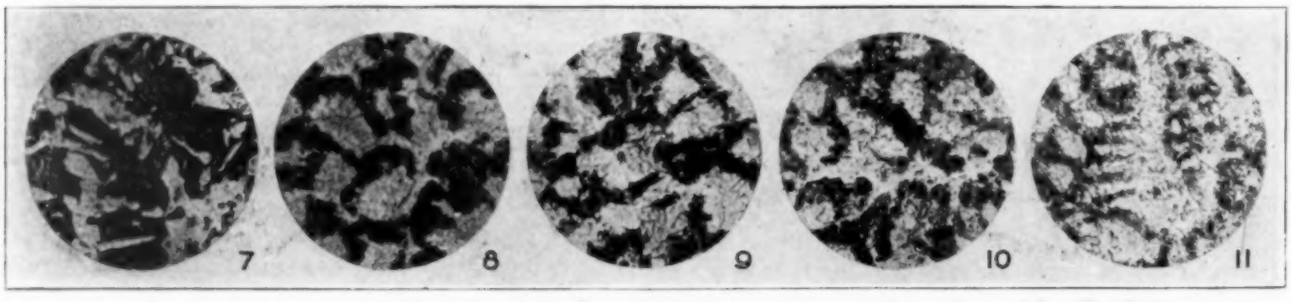
How Ingotism Exhibits Itself

When steel is cast in quite large masses, either in ingots or in formed castings, the phenomena of ingotism always appear with a great deal higher intensity than when it is cast in smaller sections. This is due to the well-known fact that the slowness of cooling during the solidification range enhances the phenomena of intercrystalline liquation and segregation. Ingotism also shows a greater intensity when massive castings contain large quantities of emulsified inclusions. Evidently the steel then feels the effects of even a mild homogeneity heat-treatment a great deal more than it would were it cast in smaller masses.

As an example of this fact, take the case of an acid open-hearth steel having the following composition:

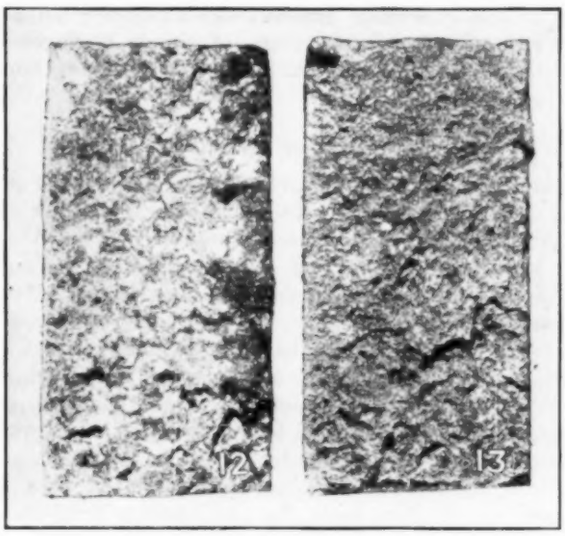
	Per Cent
Carbon	0.47
Manganese	0.63
Silicon	0.27
Sulphur	0.029
Phosphorus	0.03

Rough castings weighing more than ten tons each for 381 mm. gun cradles were made with this steel. One of these castings was heated for twelve hours at 750



FIGS. 7 TO 11

Structure of 0.25 C acid steel ingot after various heat-treatments. × 100. Etched with alcoholic solution of picric acid.



FIGS. 12 AND 13
Impact fractures of massive 0.47 C steel casting after different heat-treatments.

deg. C. Tension test-piece (cylindrical bars 13.8 x 100 mm.) and Charpy impact samples (30 x 30 x 160 mm., with a cylindrical notch 4 mm. in diameter) were then cut from the body of this casting.

The results of these first physical tests are contained in Table IV. The pulled test-piece was stretched throughout all its length, and the fracture of the impact bar revealed a coarsely crystalline structure, Fig. 12. These properties correspond well to the microstructure and are indicative of strong ingotism partly due to the presence of a large proportion of inclusions.[1]

The same casting was reheated for seven hours at 850 deg. C. and then left to cool in the air, so that its temperature dropped to 400 deg. C. in about three hours. The effect of the heat-treatment upon the structure consisted of a remarkable dissemination of the massive ferrite. Equally remarkable are the effects upon the physical properties, as shown in the table.

The tension test-piece did not show the least stretching along its length which produces the characteristic dappled surface, and the impact fracture exhibited a finely crystalline and partly fibrous structure shown in Fig. 13.

These data well indicate the mechanical characteristics by which ingotism appearing in thick masses of cast steel exhibits itself, especially when the metal contains large quantities of emulsified inclusions. In fact we must conclude that the "normal" properties of this steel are still altered or disguised even after the long heating at 750 deg. C.; denoting by the term "normal" properties the average resulting from the superposition of the specific properties of its individual normal structural constituents. Were this not the case, there can be no doubt that the effect of the second heating at 850 deg. C., followed by slow cooling, should have changed the physical properties of steel, in an *opposite* direction to those which in reality it has produced. The above examples confirm the idea that the average properties as usually determined on steel affected by ingotism are most probably due to the distribution and the continuity of the structural constituents rather than to the specific properties of the constituents themselves.

TABLE IV. HEAT-TREATMENT OF MASSIVE CASTINGS CONTAINING 0.47 PER CENT CARBON

Heat-Treatment	Tensile Strength	Elongation	Charpy Impact, Kg.-M. per Sq.Cm.
Heated for 12 hr. at 750 deg. C.	76,200	19.0	1.2
As above, then reheated 7 hr. at 850 deg. C. and air-cooled	88,000	24.0	3.61

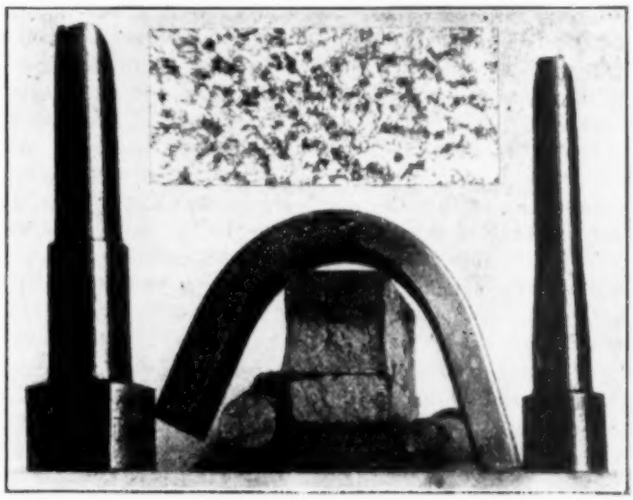


FIG. 15. TESTS ON 0.21 C CASTING AFTER NORMALIZING AT 850 DEG. C.

[1]An extended contribution on the effect of oxidized inclusions in steel will be published shortly in CHEMICAL & METALLURGICAL ENGINEERING.

FIG. 14. TESTS ON RAW 0.21 C STEEL CASTING

TESTS ON SPECIAL STEELS

We should now sum up the conclusions we have reached regarding the results obtainable by various homogeneity heat-treatments when applied to castings for machine parts when manufactured of the types of steels more frequently used for such purposes.

In order to give examples which conform to normal industrial conditions, I shall select steels of the average purity usually attained in steel foundry operation. This observation holds not only for "structural" or (improperly called "metallic") impurities such as sulphur, phosphorus, copper, etc., but also for the "foreign" or "non-metallic" impurities, especially the solid inclusions.

Results will be given for the usual physical tests—i. e., tensile, static bending, and impact upon a nicked

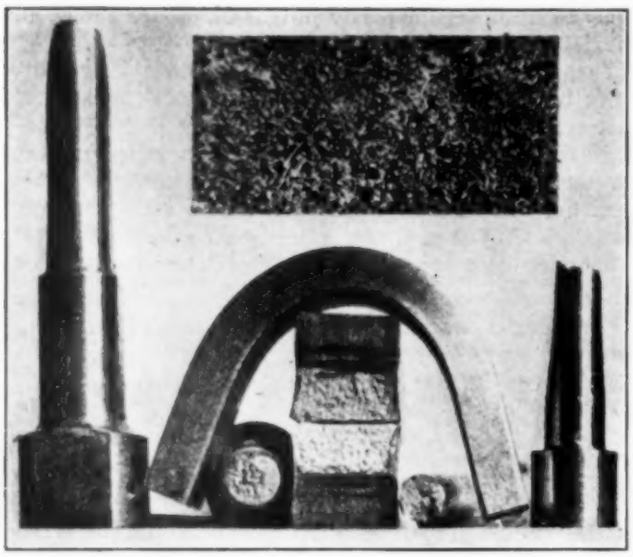


FIG. 16. TESTS ON 0.21 C CASTING AFTER AIR-QUENCHING

bar. In addition to these it will be useful to add the results of a impact tension test, made by the well known method using Charpy's pendulum striking a fixture holding a cylindrical test-pipe 10 mm. in diameter by 50 mm. long between the conical heads. The breaking work will be indicated in kilogram-meters, and refers to the initial cross-sectional area of the test-piece. All the static tensile tests referred to in the following paragraphs of this chapter were made upon cylindrical test-pieces 13.8 mm. in diameter by 50 mm. between reference points. Static bending tests were made upon rectangular prismatic bars 9.5 x 20 x 160 mm. The test-pieces were placed horizontally upon one of its 20-mm. faces, upon two parallel hard steel rolls 70 mm. in diameter, spaced 140 mm. apart on centers, and free to turn around their axes. The test-piece was forced to bend by pressure imposed upon the upper face by means of a 40-mm. steel cylinder whose axis was placed parallel to the end supports and so arranged that it could move up and down a vertical plane passing midway between. Pressure was maintained until the two ends of the test-piece were bent enough to slip between the two supporting cylinders, so that at the end of the test the piece was bent like a U with almost parallel legs.

The examples to be mentioned in the following paragraphs are especially interesting when the physical properties obtainable by means of simple homogeneity reheatings are compared to those resulting from homogeneity quenchings.

Effect of Carbon

Starting with ordinary carbon steels for making castings, data relative to two steels containing 0.21 per cent and 0.34 per cent carbon are gathered in Tables V and VI. Merely for comparison, data obtained from forged test-pieces of the same steels have been added. Working was done at about 1,000 deg. C., bringing a square bar 100 x 100 mm. down to 35 x 35 mm. Pieces for the various physical tests were always cut from the forged bars in a *longitudinal* direction—that is to say, with their long axis parallel to the direction along which the steel had been extended by forging.

In the figures reproducing the appearances of the tension and bending tests the two tension tests shown on the left are those broken under a gradual pull, while the two at the right are those broken under longitudinal impact. The slow bend test is shown above in the center, while below is the fracture of the piece broken by the Charpy impact pendulum. These figures are reduced to about half natural size. Microstructure

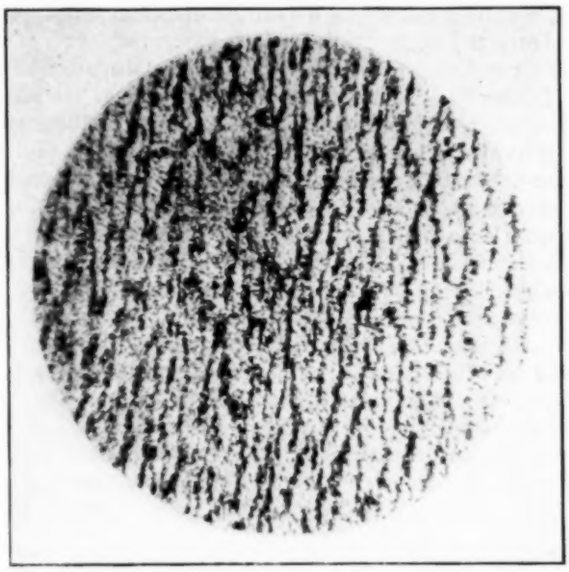


FIG. 17. MICROSTRUCTURE OF FORGED 0.21 C BAR. NORMALIZED. × 80. ETCHED WITH HNO_3 IN AMYL ALCOHOL

TABLE V. STEEL "A," CONTAINING 0.21 PER CENT CARBON

Treatment	Static Tensile Test: Tensile Strength Lb. per Sq.In.	Static Tensile Test: Elastic Limit, Lb. per Sq.In.	Static Tensile Test: Elongation per Cent	Static Tensile Test: Reduction of Area, per Cent	Impact Tensile Test: Tensile Strength Kg.-M.	Impact Tensile Test: Elongation per Cent	Charpy Impact Kg.-M. per Sq.-Cm.	Static Flexure	Microstructure and Tests
Raw casting	75,700	42,700	25	33.5	121	32	4.62	Good	Fig. 14
Casting heated at 850° C. for 3 hr. and cooled slowly	77,700	53,000	27	42	124.5	33	8.13	Good	Fig. 15
Casting heated at 850° C. quenched in air and drawn at 550° C.	79,600	55,800	28	45	128	31	9.89	Good	Fig. 16
Forged bar, reheated like casting No. 2 for 3 hr. at 850° C. and cooled slowly	80,600	55,800	32	60	112.8	29	17.12	Good	Fig. 17

TABLE VI. STEEL "B," CONTAINING 0.34 PER CENT CARBON

Treatment	Static Tensile Test: Tensile Strength Lb. per Sq.In.	Static Tensile Test: Elastic Limit, Lb. per Sq.In.	Static Tensile Test: Elongation per Cent	Static Tensile Test: Reduction of Area, per Cent	Impact Tensile Test: Tensile Strength Kg.-M.	Impact Tensile Test: Elongation per Cent	Charpy Impact Kg.-M. per Sq.-Cm.	Static Flexure	Microstructure and Tests
Raw casting	86,800	51,200	18	21	29.5	7	1.7	Broke	Fig. 18
Casting heated at 850° C. for 3 hr. and cooled slowly	85,500	54,800	25	33.5	83.3	18	6.15	Good	Fig. 19
Casting heated at 850° C. quenched in air and drawn at 550° C.	90,600	63,300	24	40.5	135	27	7.41	Good	Fig. 20
Forged bar, reheated like casting No. 2 for 3 hr. at 850° C. and cooled slowly	88,900	59,000	30	53	132	34	11.75	Good	Fig. 21

is at an enlargement of 60 diameters, after etching with nitric acid in amyl alcohol.

Two steels, which will be indicated with the letter A and B respectively, had the following chemical composition:

	A	B
	Per Cent	Per Cent
Carbon	0.21	0.34
Manganese	0.94	0.96
Silicon	0.19	0.19
Sulphur	0.03	0.02
Phosphorus	0.07	0.06
Copper	Traces	Traces
Arsenic	Traces	Traces

Evidently they can be considered as differing only in carbon, inasmuch as the variations in all the other elements are within analytical accuracy.

It is easy to see that all the numerical data contained in the two tables, as well as all the structures reproduced in the fourteen corresponding figures, find a clear

FIG. 18. TESTS ON RAW 0.34 C STEEL CASTING

interpretation in the considerations developed in the preceding chapters.

The general fact may again be pointed out from the two examples that the differences between the effects produced by annealing and those produced by quenching are less remarkable the lower the carbon content, all other conditions being equal. For confirmation, compare the data contained in the tables and the corresponding half-tones.

Comparing the microstructure and the physical properties of the cast sample No. 3 (rapidly cooled in air and drawn) with those of the same steel when forged and annealed (No. 4) gives a concrete example of what has been said regarding the possible errors resulting whenever it is thought that the average homogeneity of all components in a steel can be judged on the basis of a microscopical examination which, in reality, reveals only the distribution of the carbon. In the present case, for instance, the results of the physical tests reveal a greater persistency of the original chemical heterogeneities in tests 3 of both steels than in tests 4, while the microstructure of tests 3 actually appears much more uniform than that of tests 4.

Tests on Complex Nickel-Steel Casting

Information will now be given for a nickel steel more responsive to homogeneity heat-treatments. Contrary to the experiments upon simple test-pieces described

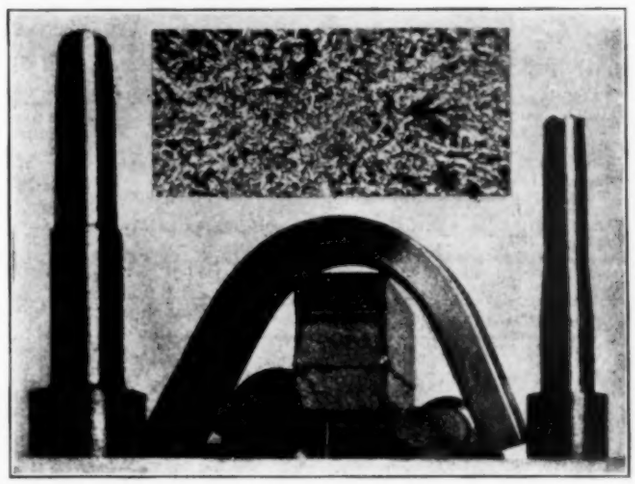


FIG. 19. TESTS ON 0.34 C CASTING AFTER NORMALIZING AT 850 DEG. C.

previously, the present results were obtained by subjecting a casting of intricate form to various heat-treatments. For this reason the following data will give an idea of the results which can be readily obtained in the practical application of homogeneity heat-treatments.

Steel used for these experiments was made in the acid open hearth and had the following composition:

	Per Cent
Carbon	0.26
Manganese	0.90
Silicon	0.18
Sulphur	0.02
Phosphorus	0.04
Nickel	1.76

Twenty-three pieces like that detailed in Fig. 22 were cast from the same heat. Pieces for physical tests were taken from the thicker part of the wall of the partly square partly cylindrical bore shown in section in the lower right part of the drawing. The whole casting had previously been subjected to a given heat-treatment.

For information and as a datum, I might add that a bar taken from an ingot of the same heat, after being forged and reheated at about 850 deg. C., gave the following results in tension when using a cylindrical

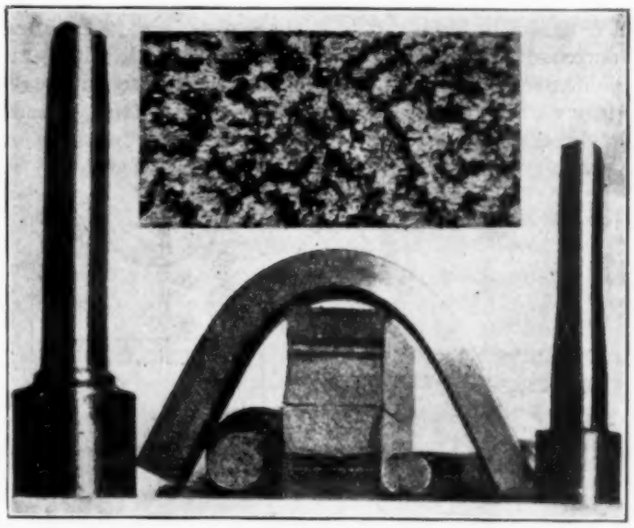


FIG. 20. TESTS ON 0.34 C CASTING AFTER AIR-QUENCHING

TABLE VII. TESTS ON NORMALIZED CASTING OF MILD NICKEL STEEL

Treatment	Static Tensile Test: Tensile Strength Lb. per Sq.In.	Static Tensile Test: Elastic Limit, Lb. per Sq.In.	Static Tensile Test: Elongation, per Cent	Static Tensile Test: Reduction of Area, per Cent	Impact Tensile Test: Tensile Strength, Kg.-M.	Impact Tensile Test: Elongation, per Cent	Resiliency, Kg.-M. per Sq.Cm. (Charpy test-piece)	Test Piece of Static Flexion
Heated at 800° C. for 4 hr., followed by rapid cooling in air, completely cooled in 1 hr.	96,000	56,000	15	14	106	12	5.1	Good
Heating and cooling as No. 1, then drawn 1 hr. at 700° C., followed by cooling in 6 hr.	86,800	52,500	21	22.5	117	27	7.5	Good
Heated at 800° C. for 4 hr., followed by a slow cooling in the furnace, requiring 18 hr.	92,200	52,000	28.5	39.8	145	35	8.22	Good
Reheating and cooling as in No. 3, then drawn at 700° C. for 1 hr., followed by slow cooling (6 hr.)	91,700	52,600	33	52.8	142	33	33	Good

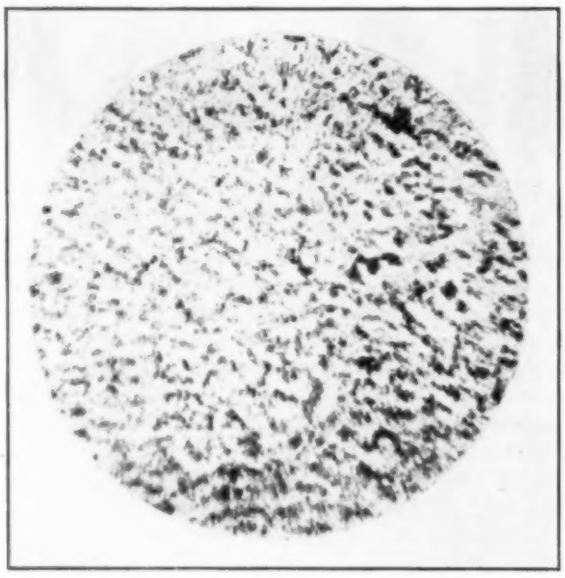


FIG. 21. MICROSTRUCTURE OF FORGED 0.34 C BAR. NORMALIZED. × 80. ETCHED WITH HNO_3 IN AMYL ALCOHOL

test-bar 20 mm. in diameter and 200 mm. long between reference points:

Tensile strength ..... 99,500 lb. per sq.in.
Elongation ..... 17 per cent.

The results of the physical tests made on castings subjected to various indicated heat-treatments are gathered together in Table VII. The numerical data contained in this table do not need explanation and find easy interpretation in the body of considerations developed in the previous part of the book. However, it is useful to point out that these data, especially when compared with those just given, clearly substantiate a phenomenon known to be related to the relative frequency of the centers of ferrite crystallization. Special steels of this type are characterized by centers of secondary crystallization closely packed together. It is therefore a great deal less dangerous to cool such special steels through the transformation range slowly, after a given homogeneity heat-treatment, than it is to do the same thing with an ordinary carbon steel. From this special point of view it is especially interesting to compare the differences between No. 2 and No. 3 of Table VII with the corresponding values contained in Tables V and VI.

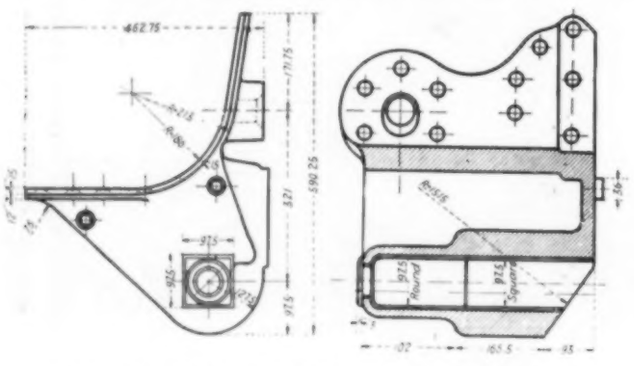


FIG. 22. DETAILS OF NICKEL STEEL TEST CASTING

(Part II will be published in a subsequent issue.)

Reparation of War Damages in the Pas-de-Calais District

The Pas-de-Calais district was one of the principal sufferers from the war. The amount of damage done, exclusive of the heavy losses to the mines, estimated on a basis of values in 1914, reached 325,000,000 fr., apportioned approximately as follows: Damages to real estate, 138,000,000; for tools and appliances damaged or removed, 122,000,000; for the destruction and requisitioning of raw materials, 54,000,000; and for the destruction or requisition of manufactured articles, 11,000,000.

As the greater number of the establishments damaged were completely destroyed, large sums will be necessary for the reconstruction of this department. Already the amount for clearing away alone has reached over 8,000,000 fr., and advances of all kinds accorded to industrial companies for war damages exceed 200,000,000 fr. Of this, 120,000,000 has been allotted in money for urgent reparations, the reconstruction of buildings, transportation, administration expenses and the direct purchase of machinery, raw materials, etc. Of 1,551 industrial companies damaged, 400 have been set going again and 16 per cent of the labor employed before the war is now re-employed again.

Most of the reconstruction work already done has been in those industries connected with the manufacture and use of construction materials. Although much affected by the lack of coal, the brick and tile factories and the limekilns and quarries are producing to their utmost. The products of these industries are being used as rapidly as possible in the rebuilding of the 66,000 houses totally destroyed and valued at 1,320,000,000 fr., and the 29,000 houses partly destroyed, valued at 290,000,000 fr.

French Beet and Sugar Output

The official forecast for the French production of sugar beets for the 1920-21 period, as recently published in the *Review* of the American Chamber of Commerce in France, is placed at 1,919,538 tons of beets, as compared with 1,130,907 tons for the previous year, or an increase of 69.7 per cent. Refined sugar production is estimated to be 244,260 tons, as compared with 143,328 tons in 1919-20. This represents an increase of 70.4 per cent.

The Rise and Development of the Electrolytic Alkali and Chlorine Industry in Europe—II

An Outline of the Electrolytic Cells Employed in the Electrolytic Alkali and Chlorine Industry of the United Kingdom, Germany, Austria, France, Italy, Switzerland, Russia and Belgium*

BY JOHN B. C. KERSHAW, F. I. C.

Electrolytic Alkali and Chlorine Industry in Germany

AS STATED in Part I of this article, the first successful electrolytic alkali works was that started in the year 1890 at Griesheim, near Frankfort, in Germany, the cell used being a diaphragm type of cell patented by the Elektron Co. According to Lunge, the experimental work which led up to the design of the Elektron cell was initiated by three German electrical engineering firms in 1884, a common fund being raised for this research work. The success which crowned the effort gave the Germans a distinct lead for many years in this new branch of the chemical industry.

The original Elektron works, at Griesheim, started with only 200 hp., but in 1892 it was doubled in size. At this period the writer was studying chemistry at Bonn University, and while there he heard with great surprise that success had been achieved at Griesheim in the manufacture of alkali by electrolytic methods, for at this date no one connected with the older LeBlanc alkali industry believed in the practicability of the electrolytic processes.

The Griesheim works having proved the value of the cell and process, a larger works was planned at Bitterfeld, in Saxony, where extensive lignite deposits are found, and this plant commenced work with 2,000 hp. in 1894, and was doubled in size in 1895.

COMPARATIVE EFFICIENCIES OF THE LEADING TYPES OF ELECTROLYTIC ALKALI AND CHLORINE CELLS
(Allmand & Kershaw's figures)*

Type of Cell	Cathode Efficiency	Energy Efficiency	Emf. in Volts	Conc. of Caustic Liquor	Kw.-Hr. per Kg. NaOH
Finlay	98	75	3.0	2N	2.0
Billiter-Siemens	92	68	3.1	3N	2.3
Vorce	97	62	3.6	?	2.5
Billiter-Leykam	95	59	3.7	3 to 4N	2.6
Allen-Moore	91	59	3.5	2½N	2.6
Whiting	92	53	4.0	5N	2.9
Hargreaves-Bird	85	..	3.7	3N	...†
Nelson	86	53	3.8	3N	2.9
Castner (rocking-cell)	92	50	4.2	5N	3.1
Kellner (C anodes)	95	49	4.5	5 to 6N	3.1
Bell-jar (Aussig)	85	49	4.0	2N	3.1
Griesheim (carbon)	70-80	45-51	3.6	1 to 2N	3.0 to 3.4
Wilderman	97	45	5.0	5 to 6N	3.4
Kellner (Pt. anodes)	97	45	5.0	5 to 6N	3.4
Townsend	94	45	4.8	4N	3.4
Griesheim (magnetite)	70 to 80	40 to 46	4.0	1 to 2N	3.3 to 3.8
Outhenin, Chalandre	66	41	3.7	2N	3.7
Theoretical figures	100	100	2.3	..	1.54

* Copyrighted by the author.
† This cell produces Na_2CO_3 not NaOH.

The developments of the Elektron cell and process in Europe since that year have been remarkably rapid and have proved the value of being first in the field, for although the financial results of the subsidiary companies have not always been satisfactory, the orders for plant and machinery which have been placed with German firms and the demand for German chemists and managers to take charge of these works in France, Russia, Austria and other European countries have no doubt amply compensated for the cost of the original research work carried out between 1884 and 1888 by the Allgemeine and other German electrical engineering companies. According to the writer's own figures, there were in 1907 already nine works in operation using the Elektron cell and process, the aggregate power utilized in these being 18,800 hp. Allmand, in 1912, estimated the aggregate capacity of the Elektron works at 33,000 hp., and stated that the Elektron or Griesheim cell was the most important of its type in use in Europe at that date. Its success is ascribed chiefly to its simplicity of design and low costs for repairs and maintenance, since its current and energy efficiency are comparatively low. (See accompanying Table.)

THE GRIESHEIM ELEKTRON CELL

The following description of the Griesheim cell is based largely upon that given by Allmand in the works already referred to.

The cell (Fig. 9) consists of a rectangular iron vessel, steam-jacketed, and covered externally with some non-heat-conducting material. This outer vessel contains a series of inclosed porous cement boxes about 1 cm. thick, which contain the carbon or magnetite anodes, and themselves act as diaphragms.

The advantage of magnetite as anode material for electrolytic alkali cells is that the chlorine gas is obtained free from CO_2; and it is claimed also that magnetite electrodes have a life of two years, even under the unfavorable conditions obtaining in the Griesheim cell. The magnetite anodes are of cylindrical shape, and are cemented to the lids of the anode boxes.

The chloride of sodium or potassium used in these cells is introduced into the anode chamber in the solid state, by a pipe reaching almost to the bottom of the cell, and is used in the pure form. The walls of the outer vessel act as cathodes, and in addition pieces of sheet-iron are suspended between each couple of anode cells.

The anodes and cathodes in each set of cells are connected in parallel and a current of 2,200-2,500 amp. is employed. The working temperature is high (90 deg. C.) and the concentration of caustic soda obtained in the cathode chamber is low, owing to the low current density employed and to the action of the current upon the sodium hydrate as it is formed. The solution in the anode boxes is kept saturated with NaCl (or KCl) and the caustic alkali solution is drawn off intermit-

*For Part I see CHEMICAL & METALLURGICAL ENGINEERING, vol. 24, No. 2, Jan. 12, 1921, p. 77.

tently from the outer compartment of the cell. The emf. used varies from 3.6 to 4 volts. This low voltage is due to the fact that only a comparatively low current density can be employed and that the conductivity is increased by heat. When producing a liquor in the cathode chamber containing 80 g. NaOH per liter, in

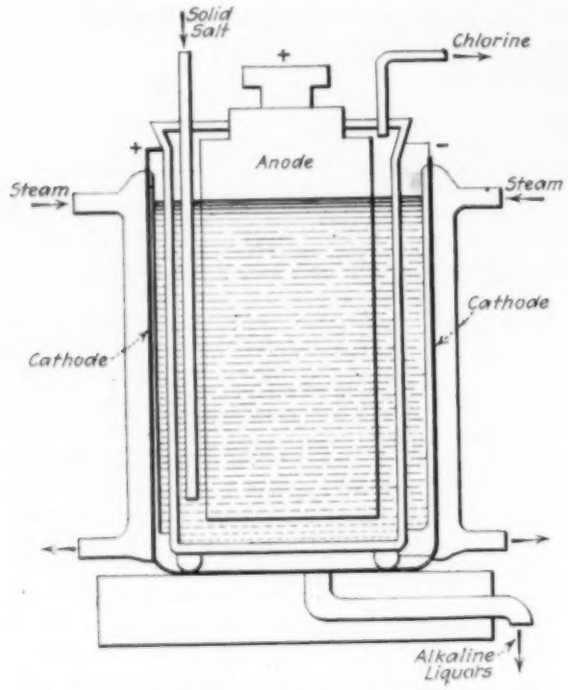


FIG. 9. THE GRIESHEIM OR ELEKTRON CELL

fact, the current efficiency of the cell is only 70 per cent. This can be raised to 80 per cent if liquor of only one-half of this strength is produced. The high temperature of the anode chamber causes the production of chlorates, which can be separated by crystallization when potassium chloride is being electrolyzed, since the potassium salt is not a very soluble product, but the sodium chlorate cannot be separated in this manner and is therefore lost.

The electrochemical works at Bitterfeld is operated entirely with electric power, derived from the very extensive beds of lignite which occur in the vicinity. The site of this works was chosen by the promoters because it was believed that the cheapness of the power would more than counterbalance the distance of the

FIG. 10. EXTERIOR VIEW OF THE ELECTROCHEMISCHE WERKE AT BITTERFELD

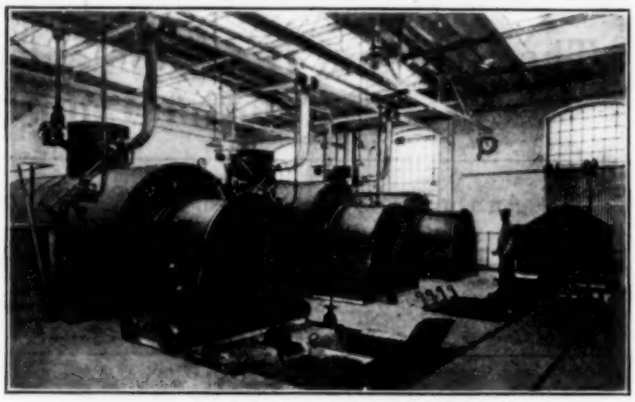


FIG. 11. GENERAL VIEW OF BOILERS FOR BURNING LIGNITE IN GERMANY, WITH STEP-GRATES BELOW FLOOR LEVEL

works from the usual markets for the manufactured goods. Very few details of the power plant have been allowed to appear in print.

Air-dried lignite is finally burned under tubular boilers with step-grates. Fig. 11 shows a general view of the charging floor of the boilers. The grate is sunk below the floor level, and the lignite is tipped directly into the charging hoppers from the tip wagons, in which it is brought into the boiler house. A sliding door, divided into three sections, regulates the admission of the fuel to the grate of each furnace. The

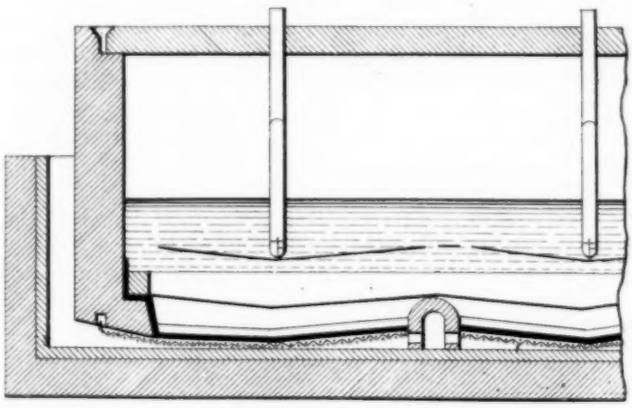


FIG. 12. THE BILLITER-SIEMENS CELL

angle of the step-grate can be altered from the ground level. The whole of the lower part of the grate is inclosed and the admission of air is regulated by levers which open or close the doors in front of the under-furnace space. The air required for combustion is drawn through a system of pre-heating stoves. As the use of the step-grate causes a very gradual evolution of the gaseous matter of the fuel, little or no smoke is produced and a secondary air supply, though provided for, is seldom required.

Trials carried out with this equipment have shown efficiencies ranging from 67 to 69.71 per cent. When using a fuel having a low heating-value, from 2.66 to 3.01 lb. of water were evaporated per lb. of fuel, the rate of burning varying from 3.1 to 4.1 lb. per sq.ft. of heating surface.

The Billiter-Siemens Cell

This cell was patented in 1907 by an Austrian chemist, Dr. J. Billiter. The patent rights for Europe then passed into the hands of Siemens & Halske of Berlin.

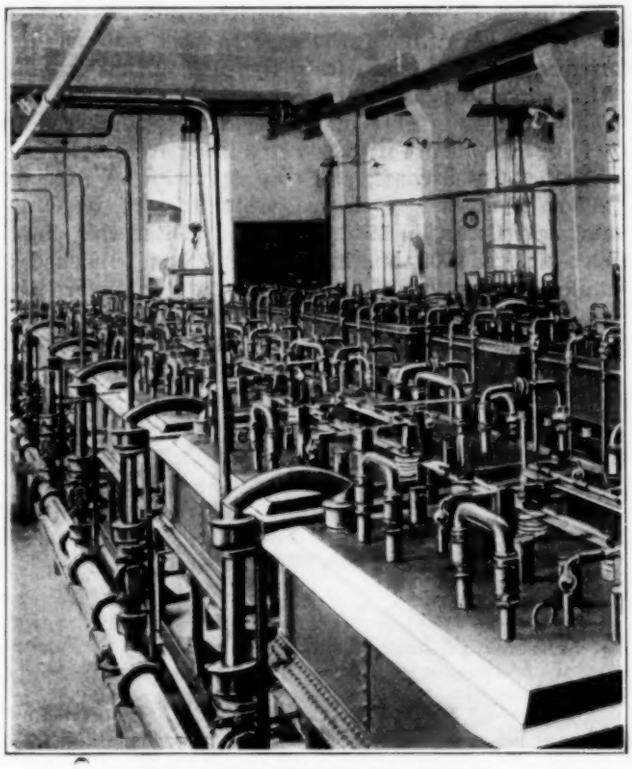


FIG. 13. BILLITER-SIEMENS CELLS AT SPIRO & SOHNE PAPER WORKS, BOHEMIA

and the cell is now known as the Billiter-Siemens cell. Before the war it was in operation in two works in Germany, two in Austria and one in the United States.

The cell is of the submerged diaphragm type (see Fig. 12), but the diaphragm is placed horizontally and not vertically, and it lies practically on the bottom of the cell, resting upon the iron gauze which forms the cathode of the cell. Above the diaphragm are placed inverted boxes or bell-jars, constructed of cement or slate, cemented at their lower edges to the diaphragm and containing large horizontal graphite anodes. The anode chambers are provided with pipes for feeding in the fresh brine solution, for leading away the chlorine gas liberated and for heating the electrolyte. The diaphragm of the cell is formed of asbestos-cloth, covered on its upper surface with a mixture of asbestos wool and fine barium sulphate, which prevents convection and diffusion losses and yet possesses a low electrical resistance. This horizontal layer of fine but well-graded inert material is the novel feature of the Billiter diaphragm. The cathode net, with the diaphragm resting upon it, is bent slightly upward in order to permit the escape of the hydrogen formed on its under surface. Several of these anode boxes or bells are contained in the outer vessel, which may be square or oblong in shape.

At Aschersleben long, narrow troughs are employed, with granite side-walls and iron bottoms, which thus serve to make electrical contact with the cathode net resting upon them. There are ten cells, each designed to utilize a current of 2,000 to 2,500 amp. and to yield a caustic potash liquor containing 18 to 23 per cent, with an expenditure of 1,000 kw. The chlorine obtained from the cell is remarkably pure, and the current efficiency is as high as 95 per cent, with an emf. of only 3.66 volts per cell.

Another form of the Billiter-Siemens cell had been introduced before the war at the sulphite paper-pulp works of Spiro & Söhne, at Krummau, in Bohemia. The cells are very much reduced in size from the earlier trough type. They are constructed of boiler-plate, with a thick cement lining along the four inner sides, in order to confine the current to the bottom of the cell. This bottom, as before, is in contact with the iron-gauze cathode upon which the diaphragm rests. Each cell contains twelve graphite anodes, connected in parallel, the cells themselves being connected in series. Each cell takes 500 amp. and the total power used in the thirty-two cells installed is 65 kw. The chlorine produced at this plant is absorbed by milk of lime and is used in the form of calcium hypochlorite solution for bleaching purposes. The caustic soda liquor produced is sold in the liquid form, as facilities for concentrating it and obtaining the solid product are lacking.

The only other type of electrolytic alkali cell in use in Germany before the war was the Solvay mercury cell,[1] at the works of the Deutsche Solvay Co., at Osternienberg. This works was started in 1896 and utilized 1,500 hp. for the manufacture of caustic potash and bleaching powder.

Manufacture of Hypochlorite of Soda in Germany

As regards the manufacture of hypochlorite of soda by electrolytic methods in Germany, only two forms of cell have been used extensively—namely, the Haas & Oettel cell and the Kellner cell.

Electrolytic methods of producing bleaching solutions have been widely adopted in Continental Europe. Before the war many hundreds of these installations were to be found scattered all over the Continent, wherever cheap electric power was available. More recently the tendency in Germany has been to produce the chlorine in the ordinary type of electrolytic alkali cell and to absorb this chlorine in milk-of-lime before using the calcium hypochlorite as the bleaching agent. Siemens & Halske have convinced themselves, by actual trials, that this plan is the more efficient and economical. The high price of platinum has of course operated to prevent the further adoption of the Kellner electrolyzer, but the Haas & Oettel type is stated to be still employed in Germany, where sodium hypochlorite solutions are required for bleaching fine cotton or linen goods.

Electrolytic Alkali and Chlorine Industry in Austria

In Austria four types of cell have been employed for the electrolysis of brine solutions—namely, the Aussig bell type of gravity cell, the Billiter-Leykam cell, the Billiter-Siemens cell and the Kellner mercury cell.

The Aussig Gravity Cell

In the Aussig gravity cell no diaphragm is employed to separate the anode and cathode compartments of the cell, but the greater density of the caustic soda formed at the face of the cathode is relied upon to effect its separation from the unaltered brine solution in the remainder of the cell. Fig. 14 shows a sectional elevation of the Aussig bell cell; *a* representing the anode, *c-c* the two sections of the ring-shaped cathode and *d* the bell which surrounds the anode and serves to collect the cathode gas. The successful operation of a cell of this type depends chiefly upon very careful control, not only of the specific gravity and of the rate

[1] See CHEM. & MET., vol. 24, p. 79, where this cell is described.

of flow of the brine solution but also of the current density and of the relative positions of the electrodes to each other and to the lower edge of the bell.

The failure to study all the conditions required to obtain success with gravity process led to the failure of this type of cell at St. Helens in the years 1896-1900; but at the works of the Oest. Verein f. Chem. Produktion, situated at Aussig, the open bell cell has been in successful operation since 1899, and a current efficiency of between 85 and 90 per cent is said to be obtainable with it. The strength of the solution of caustic soda obtained runs from 100 to 150 g. per liter Na_2O.

The costs for maintenance and repairs are of course very low and the absence of a diaphragm reduces the emf. required to work the process to 4½ volts. On the other hand, a low current density must be employed, and the bell can be constructed only of small dimensions, so that a large number of bells are required to produce a large output.

The Billiter-Siemens and Billiter-Leykam Cells

The Billiter-Siemens diaphragm cell, which has been already illustrated and described,[2] was operated before the war at Bruckl, in Bosnia, by the Bosnische Elektricitäts Gesellschaft, with sixty-four 2,500 amp. units, similar in type to those installed at Aschersleben.

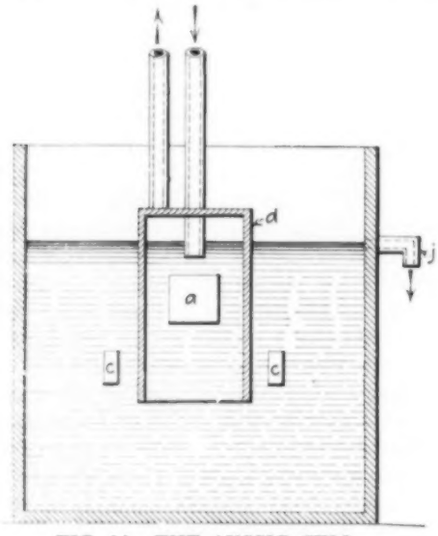


FIG. 14. THE AUSSIG CELL

Dr. Billiter, however, in 1910, designed and patented another cell which dispenses with the diaphragm of his earlier type and is known as the Billiter-Leykam cell. According to Allmand, this was one of the most efficient cells that had been operated technically before the war. The cell is shown in Fig. 15 and is seen to be a modification of the Aussig bell type of gravity cell.

The chief feature of the cell is the design and arrangement of the cathodes underneath the bell-jar. These cathodes are constructed of T-iron, inclosed in woven asbestos bags or tubes, and are sufficiently inclined to allow the hydrogen to pass away readily by the opening marked 16 in the diagram; while the caustic liquor descends to the bottom of the cell, and passes away by the channel marked 4.

According to Allmand, it is unnecessary to purify the brine at all with this type of cell; and the asbestos sheath of the cathodes is woven as coarse as is consistent with its purpose of collecting and leading away from the anode bell or hood the hydrogen gas formed underneath it at the cathodes. In this way all disturbance of the liquor within the bell by the escaping hydrogen bubbles is avoided.

The Austrian rights of this cell were purchased in 1911 by the firm of paper manufacturers, Leykam Josefsthal Gesellschaft, and an installation of fifty-six 1,200-amp. units was started at its factory, at Gratwein, near Gratz, in 1912. Allmand visited this plant, which utilized 500 hp. in 1912, and has published a detailed description of it in a paper read before the Faraday Society in November of the same year. The current efficiency is about 92 per cent, and the emf.

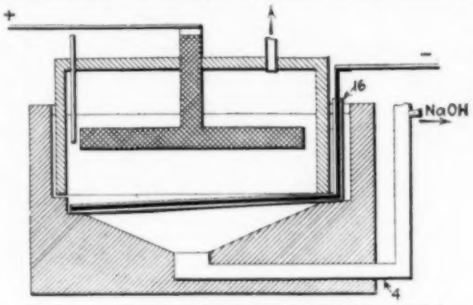


FIG. 15. THE BILLITER-LEYKAM CELL

required at 65 to 70 deg. C. is 3½ volts. The cathode liquors contain on an average 12 to 13 per cent NaOH; but by decreasing the rate of flow of the brine, 16 per cent NaOH can readily be obtained.

The Kellner Mercury Cell

The Kellner type of mercury cell has been worked by the Consort. für Electrochem. Industrien at Golling, in Austria, and at Jaice, in Bosnia, since 1900; but again there is no information available as to what has happened to these works during the war period.

The first-named works was only a small one of 200 hp., but at Jaice, in Bosnia, there was a large hydro-electric installation capable of producing over 10,000 hp.

The Kellner mercury cell at both of these works differed from that used at Weston Point in that compressed air was employed to circulate the mercury. The cell was a large but shallow vessel, constructed of cement, and was divided into three compartments by transverse partitions, dipping into the layer of mercury on the floor of the cell.

The center compartment formed the anode division, and contained a number of cement hoods carrying the anodes. The two end compartments of the cell were the cathode compartments, and in these the decomposition of the sodium amalgam occurred with the aid of iron, exactly as in the original Castner-Kellner cell.

The cathode compartments were, however, provided with outside troughs in which the mercury collected, and by means of a pump this mercury was forced to travel backward and forward from the anode to the cathode compartment of the cell. The circulation is reported by Allmond to be very efficient, and to permit the use of a high current density with the cell (15 to 20 amp. per sq.dm.); but no other data concerning the operation of Kellner cell or of the works at Jaice are available for publication.

(The third and last part of the article, dealing with the Electrolytic Alkali and Chlorine Industry in France, Italy, Switzerland, Russia and Belgium, will be published in a subsequent issue.)

[2]See p. 120.

A Comparison of Various Methods of Water Purification

An Impartial Discussion on the Respective Merits and Disadvantages of Methods of Water-Softening by Filtration Through Zeolites, by Chemical Precipitation and by Rectification With Boiler Compounds

By WILLIAM MACKLIN TAYLOR

IN THE face of the claims and counterclaims set up by the manufacturers of the various processes of water purification, the layman and the chemist who have not specialized on this subject frequently experience difficulty in deciding which process is best adapted to their needs. The purpose of this article is to outline the strong and the weak points of these processes, drawing conclusions which will enable the uninitiated to decide more intelligently which process will solve his problem most successfully.

The term "water purification" is susceptible of two entirely different meanings. Water may be purified from a sanitary viewpoint and still remain as impure as before from an industrial standpoint, and *vice versa*. This article will deal exclusively with the purification of water for industrial uses.

Broadly speaking, the purification of water for industrial purposes may be divided into five classifications, which are as follows:

Distillation.
Removal of suspended matter by filtration.
Water-softening by filtration through zeolites.
Water-softening by precipitation.
Rectification by the use of boiler compound.

This article will deal principally with the last three methods mentioned and will touch on the first two very lightly.

Distillation

Wherever a water of highest purity is an imperative requirement, distillation is the only method whereby it can be produced. The cost of its production is so high, however, that its commercial use is very limited, as compared with the other methods of purification. Where the entire absence of all impurities (dissolved and suspended) is not an absolute requirement, it is frequently possible, by the use of one or more of the other methods of purification, to obtain a water which will satisfactorily meet the requirements, and thereby effect a marked economy.

Filtration

Generally speaking, when a filter has removed all of the suspended matter which a water carries, it has fulfilled its mission. The processes of filtration are too well known to justify taking the time to describe them in detail here.

There are cases where filters which would hardly fall into the third classification are used for other purposes than the removal of suspended matter. The most notable of these are the filters whose beds are composed of marble chips, whose purpose is the removal of free acid from acid waters, and the filters whose beds are composed of various forms of charcoal, whose purpose is the removal of organic coloring matter.

The water in the clouds is as pure as any natural water can be; but in passing through the air, as it falls in the form of rain, it commences to absorb impurities. As it travels over or through the earth before being used, it absorbs other impurities. The most troublesome of these are the salts of calcium and magnesium; and there is no natural supply of water known which is entirely free from them.

In cleansing operations as carried on in laundries and textile mills, the calcium and magnesium present in the water destroy soap, necessitating the use of larger quantities than would otherwise be necessary, thereby increasing the costs of operation. They form an insoluble curd-like precipitate with the soap, which adheres very tenaciously to the fibers of cloth or yarn and which causes trouble in various ways. In the laundry it causes a dirty yellowish gray appearance on the finished work, and later the organic acid to which the calcium and magnesium are united decomposes, giving off an unpleasant odor. In the textile mill it causes unevenness and breakage of the yarns in weaving, increasing the amount of "seconds." In the dyehouse it forms lakes with the dyestuffs, causing streaked and uneven dyeing. In the preparation of certain chemicals, dyes, extracts, etc., the presence of calcium or magnesium salts causes precipitates, or lowers the quality of the finished product in other ways. In the boiler room the presence of calcium and magnesium in the water is a sure forerunner of boiler scale, which, if allowed to accumulate in the boiler, causes an enormous loss of heat and thereby a proportional excess consumption of coal. By acting as a heat insulator on the wrong side of the boiler shell, it allows the metal to become overheated, shortening its life and increasing the repair bill.

Hence, from the standpoint of nearly every industrial user of water, the salts of calcium and magnesium are trouble-makers and their elimination is desirable. Since it is these salts that make water hard, their elimination renders the water soft.

There are two well-known processes by which these salts may be more or less completely removed from the water. They are: Water-softening by filtration through a zeolite filter, and water-softening by precipitation.

Zeolite Filters

There are several kinds of zeolites in use today; some are of natural origin, some are produced by the fusion of several components, and others are produced by a precipitation process. All, however, work upon the same principle, taking advantage of the same chemical law of mass action, the details of operation alone being different. It is not my purpose here to state any preference for one over another, for all do good work and efficient work in the fields to which they are adapted.

In general, the zeolite water-softener is a pressure

filter, whose bed consists of granules of a zeolite. This zeolite is usually a hydrated silicate of aluminum carrying a large amount of loosely-bound and chemically active sodium. By the law of mass action, when water containing salts of calcium and magnesium is passed through this bed of zeolite, the sodium is exchanged for the calcium and magnesium, and the water in the effluent contains only very small amounts of the substances. If we use "R" as the symbol of the acid radicals to which the calcium and magnesium are joined, and "Z" as the symbol of the zeolite, the reaction which takes place might be written as follows:

$$CaR \text{ (or } MgR) + Na_2Z = Na_2R + CaZ \text{ (or } MgZ)$$

This reaction, while very efficient from a commercial standpoint, does not proceed to theoretical completion, for a very small amount of calcium and magnesium remains in the filtered water, this amount usually ranging from 0.3 to 1.4 grains per gal., calculated to calcium carbonate. Water carrying less than the latter figure is usually referred to by manufacturers of zeolite water-softeners as water of zero hardness, although this term is really misleading.

In the author's library of water analyses, compiled during many years of work as a chemical engineer specializing on water purification, there appear many analyses of waters treated by the zeolite process. Some of these are accompanied by analysis of the same water before treatment. Probably the most representative of these is a sample of the city supply of Des Moines, Ia., taken July 3, 1917, and completed July 7, 1917. It runs as follows:

Dissolved Substance	Raw Water	Treated Water
Sodium chloride	0.58	0.88
Calcium carbonate	9.50	0.25
Magnesium carbonate	5.29	0.21
Magnesium sulphate	0.42	.....
Sodium carbonate	.....	17.44
Sodium sulphate	8.52	8.59
Iron and aluminum oxides	0.40	0.14
Silica	1.14	1.24
Total	25.85	28.75
Hardness, calculated to calcium carbonate	16.15	6.50
Alkalinity, calculated to calcium carbonate	15.77	16.94

It is obvious that the time soon comes when all of the available sodium in the zeolite has been given up in exchange for the calcium and magnesium, and an exchange can no longer take place. When this time comes, it is not necessary to replace the zeolite with new material, for it can be regenerated or restored by reversing the law of mass action, for this law operates equally well in the reverse direction. This is accomplished by soaking the filter bed in a strong solution of brine made of common salt. The calcium and magnesium which had been absorbed by the zeolite are exchanged for the sodium of the sodium chloride, forming calcium and magnesium chlorides, and the sodium is absorbed by the zeolite. After having been steeped for a sufficient length of time—which differs with the products of different manufacturers—the brine is drawn off, the free salt remaining is rinsed out till the water runs sweet, and the zeolite is again in its highly effective state.

Water which has been passed through a zeolite water-softener exhibits the following properties:

It contains a smaller amount of calcium and magnesium salts than does the water treated in any other way except distillation.

It contains a slightly higher amount of dissolved solids than the raw water.

The alkalinity to methyl orange is slightly higher and (except in case of an improperly-processed zeolite) no caustic alkalinity is added to the water. It makes a very satisfactory potable water and possesses a quite acceptable taste.

The greatest fields for the zeolite water-softener are in places where water is used for cleansing, as in laundries, textile mills, hotels and homes; or where the presence of the calcium and magnesium salts in the water cause trouble, as in the preparation of certain chemicals, extracts, dyes, etc.

Precipitation Water-Softeners

The forms of precipitation water-softeners are many, but the principle upon which they operate is the same in all: The removal of calcium and magnesium salts by precipitation and filtration. The calcium is precipitated as the carbonate, the magnesium as the hydroxide. With few exceptions, the reagents used are hydrated lime and soda ash, and the precipitations are effected in accordance with the following reactions:

$$Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O$$

$$CaSO_4 \text{ (or } CaCl_2) + Na_2CO_3 = CaCO_3 + Na_2SO_4 \text{ (or } 2NaCl)$$

$$Mg(HCO_3)_2 + 2Ca(OH)_2 = Mg(OH)_2 + 2CaCO_3 + 2H_2O$$

$$MgSO_4 \text{ (or } MgCl_2) + Ca(OH)_2 + Na_2CO_3 = Mg(OH)_2 + CaCO_3 + Na_2SO_4 \text{ (or } 2NaCl)$$

Some precipitation water-softeners have been sold which use caustic soda alone as the precipitant, but these had a very limited field, and never attained a very wide distribution. Other precipitation water-softeners at present on the market make use of barium carbonate as a precipitant in place of soda ash. These are valuable where the water contains large amounts of sulphates; but these constitute a special case, and cannot be considered at length here.

Precipitation water-softeners may be divided into two major classes: the intermittent and the continuous systems.

The continuous type of lime-soda ash water-softener (which enjoys a very much wider distribution than the intermittent type) consists usually of a large sedimentation tank provided with reagent tanks in which the weighed amount of chemicals to be used in treating the water is stirred up with a sufficient amount of water to permit of ready flow; and an apportioning device which allows the reagents to flow into the raw water in proportion to the raw-water flow. The water usually flows into a downtake, where it is thoroughly mixed with the chemicals and where the precipitation takes place. It then rises slowly in the sedimentation tank proper until it reaches the top, where it overflows through a filter, and is then ready for use. The sedimentation tank is built sufficiently large to allow such a slow upward movement of the water as not to interfere with the downward movement of the precipitates formed, as they settle in the form of a sludge, to the bottom, where they are drawn off through a valve as often as may be necessary. The standard practice is to allow four hours' time for the water to pass through this tank—i. e., the sedimentation tank is built sufficiently large to accommodate an amount of water equal to four times the rated hourly capacity.

The intermittent type of lime-soda ash water-softener consists of two or more large tanks from which the water is drawn alternately. As soon as one of the tanks is empty, it is refilled with the raw water, the necessary

amount of reagents is dumped in, and after a short period of agitation the precipitate is allowed to settle to the bottom. While this precipitate is settling, the water is being used from the other tank or tanks and by the time the supply of softened water in the other tanks is exhausted, the precipitate in the first tank is completely settled, and the water in this tank, now softened, is ready for use.

Water from the lime-soda ash water-softener exhibits the following properties:

It contains a smaller total amount of dissolved salts than the raw water.

Its alkalinity to methyl orange is usually less (except in cases of a raw water carrying a very small carbonate content), but it exhibits a small amount of "caustic alkalinity" (alkalinity to phenolphthalein). This is usually sufficient to give it a rather unpleasant, soapy taste, rendering it unfit for potable use.

It is impossible to carry the elimination of calcium and magnesium salts to the degree attained in the zeolite water-softener, the lowest practicable limit being a little over 1.6 grains per gal. of hardness, expressed in terms of calcium carbonate. In practice, the hardness of the treated water will usually run considerably above this figure, the average probably being in the neighborhood of from 3.5 to 4.0 grains per gal. The analyses which follow are those of raw and treated water from the city supply of Cedar Rapids, Ia., and are representative of the best results to be obtained from the lime-soda ash water-softener:

Dissolved Substance	Raw Water	Treated Water
Sodium chloride	1.46	1.46
Calcium carbonate	7.45	2.15
Magnesium carbonate	3.07	0.84
Magnesium sulphate	1.74	...
Sodium carbonate	.....	2.33
Sodium sulphate	8.05	10.22
Iron and aluminum oxides	0.11	0.12
Silica	0.71	0.79
Total	22.59	17.81
Hardness expressed as calcium carbonate	12.55	3.15
Alkalinity expressed as calcium carbonate	11.10	5.25

The greatest fields available for the lime-soda ash water-softener are in the treatment of water which is evaporated for steam and of water which is used for the production of raw-water ice.

Boiler Compounds

During the past two decades the use of boiler compounds has fallen into disrepute, due to two causes. Of these probably the more important has been the existence of manufacturers of unscientific formulæ—the charlatans and mountebanks of the water-purification field. The substances used in the manufacture of these compounds are legion, and they include such irrational and worthless components as sawdust, potato peelings, ground straw, malt, spent tanbark, etc. As a warning against these, I would advise every purchaser of boiler-compound to shun any compound which is claimed to give satisfactory results on every water. It is the same proposition to try to treat every human ailment with the same medicine as to treat every water with the same compound.

The other cause for the disrepute into which the use of boiler compound has fallen is the propaganda distributed by the manufacturers of water-softeners. The unscrupulous manufacturers referred to in the previous paragraph gave good grounds for this propaganda, but it was not directed solely against these. Many manufacturers of boiler compounds approach the problem of the prevention of boiler scale in a thoroughly scientific manner, maintaining well-appointed laboratories where the work is carried on by experienced chemical engineers and where the problem of the proper treatment of water is worked out with intelligence and skill.

In considering the various methods of water-purification, it is these latter boiler compounds to which I shall refer.

Exactly what takes place in a boiler under the combined effects of heat and pressure we shall never know. We can only judge from results as seen from the outside and from interior inspection after the heat and pressure have been removed.

It has been learned that the presence of certain salts in the water causes scale and the addition of certain chemicals will prevent this, causing substances which would otherwise form the scale to settle to the bottom of the boiler in the form of mud, to be disposed of in the blow-off. Certain other dissolved salts have been found to induce foaming and priming. The addition of other chemicals has been found to exert a counteracting force. The number of chemicals used in the boiler-compound field are many. A few of those used for the prevention of scale by a precipitating action are: soda ash, caustic soda, sodium silicate, tri-sodium phosphate, hydrated lime, barium hydrate, barium carbonate, barium chloride. Other chemicals which prevent the adhesion of scale by causing it to form in granules or in some other way preventing its fastening itself upon the metal are: certain mineral oils, graphite and certain tannin extracts. Some of those which have a tendency to counteract foaming are barium hydrate, barium carbonate, barium chloride, hydrated lime and certain vegetable oils.

To neutralize corrosion from free acid or from the sulphates of iron and aluminum, any alkaline salt may be used, soda ash probably being the most frequently employed. Electrolytic corrosion may frequently be overcome by the use of metallic zinc.

In general, the only field for the use of boiler compounds is in the treatment of boiler-feed waters.

General Discussion

The value of any of these systems of water-purification depends entirely upon two considerations: 1. The nature and amount of dissolved matter present in the raw water. 2. The purpose for which the water is to be used.

There are supplies of water which cannot be satisfactorily treated for any industrial use by any method with which the author is familiar; as for instance, samples of water from parts of North Dakota and Wyoming which he has analyzed and which contain magnesium sulphate in excess of 1,200 grains per gal. Some supplies can be successfully treated by one method where another method would fail utterly. It is the purpose of this article to help the engineer decide which method will give best results on his supply of water, for his purpose.

Advantages of Zeolite Type of Water-Softener

Let us consider first the zeolite type of water-softener. Its outstanding advantages are the following:

1. It produces a water which contains a smaller amount of calcium and magnesium salts than can be obtained by any other method except distillation.

2. It requires less expert attention than the lime-soda ash water-softener.

3. No chemicals are fed into the water, hence there

is no changing of amounts of chemicals to take care of fluctuations in the hardness of the water.

4. The only reagent used is common salt, and this is less subject to fluctuation in supply and price than is soda ash.

5. Because no sedimentation tank is required, the zeolite water softener requires less space than the precipitation water softener.

Disadvantages of Zeolite Type

Its outstanding disadvantages are as follows:

1. The amount of sodium salts present in the water is increased and (due to the fact that sodium, a monad, has an atomic weight greater than half that of either calcium or magnesium, both of which are diads) the total amount of dissolved matter is increased rather than diminished. If used for boiler-feed water, this would increase the tendency to foaming and priming.

2. The cost of operation, exclusive of the cost of labor, is greater than with the precipitation water-softener.

3. The capacity fluctuates with the fluctuation in the amounts of calcium and magnesium salts present in the water.

4. Disintegration of the zeolite by attrition and solution, although it may be very slight, increases the upkeep or depreciation of the installation.

5. Many waters that could be easily handled by the lime-soda ash water-softener cannot be handled by this system. Large amounts of calcium or magnesium salts or large amounts of sodium salts render its use either inefficient or impossible. A zeolite softener cannot satisfactorily handle any water containing a larger amount of iron than the average. The presence of minute quantities of manganese will in a short time render a zeolite softener incapable of softening water. If the raw water carries an appreciable amount of suspended matter, it must be filtered before passing it through the zeolite machine.

It is not my intention to weigh these advantages against the disadvantages for specific applications, but rather to point out a few general considerations governing their operation.

Type of Laundries, Textile Mills, Etc.

In laundries and textile mills, where the presence of calcium and magnesium salts causes the destruction of soap, and the curds formed by the interaction taking place between soap and these salts cause a lowering of the quality of the work turned out, for the average water the zeolite system is the logical system to use. In the preparation of chemicals, dyes, extracts, etc., where calcium or magnesium causes precipitates or lowers the quality in other ways, the zeolite system is the better system, provided only that the presence of increased quantities of sodium salts does not affect the quality. This rule holds good only for waters whose hardness is not greatly in excess of the average. For a water whose hardness ranges above about 40 grains per gal., the advisability of installing a zeolite softener presents a special problem which would have to be decided separately for each separate case. The reason for this lies principally in the fact that the raw water used to rinse out the salt used for restoring or regenerating a zeolite must be used in such quantities that with such a hard water the tendency is to reduce the capacity of the softener beyond the economical point.

Where a water contains a large amount of sodium salts, there is a tendency for the law of mass action to act in both ways during the passage of the water through the filter bed. It is as if the upper layers of the zeolite removed the calcium and magnesium, and then the water with the addition of the sodium which replaced the calcium and magnesium, being so high in sodium salts, partially restored the zeolite in the lower layers, just as the brine does. The amount of sodium salts which would cause trouble varies in different cases, and it would be difficult to formulate any rules which would hold good in all cases. The presence, however, of more than 40 grains per gal. of sodium salts or of more than 50 grains per gal. of dissolved solids is sufficient to cause the water to be viewed with suspicion.

Where a water carries a higher amount of iron than usual, or even a minute quantity of manganese (this latter is comparatively rare), or where the water contains any free acid, it is necessary to pre-treat the water before passing it through the zeolite machine. Iron or manganese dissolved in the water is absorbed by the zeolite, and in time forms a coating over the granules which interferes with the contact between the water and the zeolite; and without this contact, the exchange of the sodium for the calcium and magnesium is impossible. Free acid present in the water causes the zeolite to disintegrate more rapidly than is the case with the normal, slightly alkaline water. In addition to this, the acid water which does not carry a comparatively high amount of dissolved iron is indeed a rarity. Acid waters, however, are rarely met with outside of districts where mining is carried on or where steel mills are located.

Water Should Be Analyzed Before Decision Is Made

This may be a good place to state that it is a wise move on the part of a prospective purchaser of not only the zeolite but of any type of water-purification apparatus to have an analysis made of his water by some responsible laboratory. If the proposed installation is a large one, the prospective purchaser can well afford to protect his interests by obtaining the opinion of a reputable consulting chemical engineer; for it will frequently mean the prevention of costly trouble in the end, compared with which the consulting chemical engineer's fee would be a mere trifle.

In many cases zeolite water-softeners have been installed in private homes, in apartment buildings and in hotels and have given complete satisfaction, water treated in a zeolite machine having a pleasing flavor, and the removal of the hardness makes the water much pleasanter to use for bathing or for any cleansing operation, besides leaving the skin in better condition. Some claims have been put forth to the effect that boiled foods will cook more quickly in softened water than in the raw water, but I question it.

Advantages of Precipitation Water-Softener

Now let us turn to the precipitation water-softener. Its prominent advantages are:

1. Lower cost of operation. Ignoring the question of labor (for the grade of labor used to operate the softener varies so widely with different owners of water softeners that a just comparison is impossible), with rare exceptions, the lime-soda ash water-softener can be operated at less cost per thousand gallons of water treated than is the case with the zeolite softener.

2. Capacity remains the same, regardless of fluctuation in the hardness of the water. The fluctuations are taken care of by increasing or decreasing the proportion of chemicals to the amount of water treated.

3. The treated water carries a smaller amount of dissolved solids than the raw water and there is not as great an amount of sodium salts added to the water as with the zeolite softener. This lessens the tendency to foaming and priming, when the water is used for boiler feed.

4. There is no depreciation on account of attrition of mineral, as with the zeolite water-softener. Given equal care, the life of a precipitation water-softener should exceed that of the 100 per cent performance of the zeolite filter bed.

5. The limits of hardness or amount of sodium salts present in water which can be treated are considerably higher than with the zeolite water-softener.

6. If the water contains an appreciable amount of suspended matter, it is not necessary that it be filtered before being treated.

7. Waters containing free acid or high amounts of iron or manganese can be as effectively treated as if these substances were not present.

Disadvantages of Precipitation Water-Softener

The notable disadvantages of the precipitation water-softener are:

1. Where space is an item, the precipitation water-softener requires a much larger space than does the zeolite softener.

2. It is an impossibility to produce as soft a water as can be produced in the zeolite softener.

3. Its operation is more complicated than that of the zeolite softener; hence it requires greater intelligence on the part of the operator to make the changes in the treatment necessitated by fluctuations in the hardness of the raw water.

4. The soda ash used fluctuates in price, and is frequently difficult to obtain at any price.

5. It is difficult to obtain a water through a lime-soda ash water-softener that will be suitable for human consumption.

The water obtained by treatment through the precipitation water-softener is pre-eminently a water suitable for boiler feed or for the manufacture of raw-water ice. Prior to the commercialization of the zeolite water-softener, the precipitation system secured a wide distribution among laundries, textile mills, etc. But for ordinary waters, the zeolite water-softener soon demonstrated its superiority in these fields. In laundries and textile mills every grain per gallon of hardness left in the water represents the destruction of soap and the formation of the sticky curd caused thereby, and the fact that a softer water can be obtained with the zeolite water-softener enabled it to appropriate these fields almost exclusively to itself in territories whose water supply was not impossible of treatment by this method.

In boiler feed, however, it is not necessary that the water be softened down to the last grain per gallon in order to prevent boiler scale. The presence of a small amount of caustic alkalinity (alkalinity to phenolphthalein) in the water is not only sufficient to prevent the formation of new scale by the treated water, but it will also, in most cases, help soften and remove scale that had already formed. It is necessary, however, to watch the performance of the precipitation water-softener quite carefully to see that the water is treated properly, and that the treated water conforms to the standards of tests for such a treated water. Any fluctuation in the amount of proportions of the dissolved solids calls for a corresponding change in the amount or proportions of the chemicals fed to the water. The standard practice calls for hardness slightly less than the alkalinity to methyl orange, and for the alkalinity to phenolphthalein to be slightly greater than half that to methyl orange. The hardness may reach 5 to 6 grains per gal. in the treated water without causing scale to form.

Laundries, textile mills and other users of water whose supply is of such a nature that the zeolite water-softener cannot handle it properly may frequently obtain very satisfactory results by the use of the precipitation water-softener. As a matter of fact, one distinction between the performance of the two types of water-softeners is the fact that the zeolite machine's efficiency (within reasonable limits) increases in reverse proportion to the hardness of the water, while that of the precipitation type of machine (within reasonable limits) increases in direct ratio to the hardness of the water.

In the manufacture of ice, the smaller the amount of dissolved solids present in the water the better is the water for freezing and the less will be the necessity for core-pulling. Water treated in the precipitation water-softener contains a smaller amount of dissolved solids than does the raw water, hence the value of the precipitation water-softener in this industry. Water treated by a zeolite water-softener will contain a larger amount of dissolved solids than does the raw water, hence the zeolite machine is of no value here. This is one case where there can be no argument as to the relative values of the two types of water treatment.

There remains now the question of the relative value of water treated by boiler compounds to that treated by water-softeners. As indicated above, the only field where boiler compounds come into competition with water-softeners is in the treatment of water for use in boilers to make steam.

Advantages of Boiler Compounds

The principal advantages of boiler compounds are:

1. No expensive apparatus is necessary for the treatment of the water.

2. It is much simpler and easier to handle than is treatment through water-softeners.

3. More accurate proportioning of chemicals is possible.

4. A greater variety of chemicals may be used, effecting better results with many waters than could be obtained by the use of a water-softener.

5. There is no loss of water due to disposal of sludge, backwashing filters, etc.

Disadvantages in the Use of Boiler Compounds

The more prominent disadvantages in the use of boiler compounds are:

1. Difficulty in obtaining uniform treatment of all the water used.

2. The amount of mud collecting in the boiler is increased, rendering more frequent blowing-down necessary.

3. Actual cost per thousand gallons treated is usually greater than is the case with softened water. This is to some extent offset by interest on investment in a softener, depreciation, repairs, etc.

The salesmen for water-softeners are prone to consider boiler compounds as more or less of a joke, an unscientific way of treating water—making a water-softener out of the boiler. And, as has been intimated before, there are frequently good grounds for this attitude.

The scientific boiler compound of today, however, is really an efficient method of treating boiler-feed water, and in many cases a more scientific method than by treating the water through a water-softener, for there are frequently cases where conditions are met with which cannot be effectively handled with a merely softened water. Among these are the conditions which cause foaming and priming. The use of a water-softener will not prevent these troublesome conditions; water treated in a zeolite water-softener has an increased tendency to cause foaming; and in a water exhibiting a tendency to foaming great care must be taken in treating it with a precipitation water-softener, for the slightest over-treatment increases this tendency. On the other hand, an intelligently prescribed boiler compound will introduce chemicals into the boiler which have an active anti-foaming effect, and will actually prevent foaming.

Pound for pound, boiler compounds cost considerably more than the chemicals used for treating in a precipitation water-softener, but under the influence of heat and pressure the chemicals used carry the reactions which take place nearer to completion and a smaller amount of chemicals can be used to secure a similar effect.

Boiler compounds will have a palliative effect on waters which cannot be satisfactorily treated in either the zeolite or the precipitation water-softener.

On account of the fact that the precipitation takes place inside the boiler, it is necessary to keep closer watch on the blow-off and to prevent accumulations of mud on the flues and other heating surfaces of the boiler, for such accumulations would allow overheating of the coated surfaces which would render repairs necessary.

Precautions to Prevent Corrosion

Corrosion is usually met with in cases of acid waters. This may be as easily remedied by the use of boiler compound as by treatment in the precipitation water-softener. Soda ash is frequently the neutralizing agent employed, although in many cases where the acid present is sulphuric acid, barium carbonate or hydrate is used. This eliminates the danger of foaming which the formation of an excess of sodium sulphate would cause.

Corrosion from electrolysis is a matter of occasional occurrence in stationary boilers. In marine boilers it is nearly always present. It has been found that the use of metallic zinc will overcome corrosion by electrolysis. When metallic zinc is present in the boiler, the zinc, being electro-positive to the steel of the boiler shell, acts as the anode and is corroded in place of the steel. This fact is made use of by one manufacturer of boiler compounds by using finely pulverized metallic zinc mixed in the compound.

Methods to Insure Treatment of All the Water

In order for boiler compounds to do their work effectively, it is necessary that all of the water shall be treated. This is frequently difficult of attainment. Some manufacturers make their compound in the form of a liquid and snuff it in through the injector at stated intervals. Others manufacture their compounds in the form of bricks or of balls, and feed it through some device whereby a small stream of the water is diverted through a section of pipe containing the solid compound, dissolving a small portion and then returning to the main stream of the feed-water inlet. This requires a nice adjustment of the stream which passes over the solid compound, so that it shall dissolve enough, but not too much, but it is probably the most satisfactory method of feeding the compound.

In the small installation, the boiler compound has an immense advantage over the precipitation water-softener, for the original cost of the water-softener is greater in proportion to the rated capacity in a small installation than in a large one. In addition to this the precipitation water-softener does not work so satisfactorily on small amounts of water—say from 100 to 250 gal. per hr.—as it does on larger amounts—from about 500 gal. per hr. up.

Local Conditions Decide Method to Be Used in the Case of Large Installations

On larger installations, the question of the superiority of one or the other method of treatment depends upon local conditions. Under average conditions, boiler compound will produce better results with water-tube boilers. The author has, just this morning, inspected the turbining of a large water-tube boiler at the plant of a large chemical manufacturing concern. This boiler was in excellent condition, there being slightly less than $\frac{1}{32}$ in. of scale in the tubes, and about $\frac{1}{32}$ in. on the plates. The chief engineer of the plant told me that this was the first time in over a year that this boiler had been turbined, that they had been operated twenty-four hours per day and had been run on an overload averaging at least 25 per cent, and that during the peak of the day's run the overload frequently reached 100 per cent. The water used in these boilers is Lake Michigan water, which carries 7.6 grains per gal. (slightly over 1 lb. per 1,000 gal.) incrusting salts; and it was treated solely with boiler compound. The reason that boiler compounds will produce better results with a water-tube boiler than will the precipitation water-softener is the fact that foaming preventives can be incorporated into the compound, whereas they cannot in the softener, and a very slight over-treatment of the water in a precipitation softener will cause water to be carried over with the steam from a water-tube boiler, especially at times when the boiler is carrying an overload.

For locomotive boilers the same consideration will obtain as with the water-tube boilers, for they are more subject to trouble from foaming and priming than even the stationary water-tube boilers.

Best Method for Fire-Tube Type of Boiler

On the fire-tube type of boiler, where there is not so great danger of foaming and priming, for average waters (those running over 8 grains per gal. of incrusting salts) the precipitation softener exhibits its best results; and it is usually superior to boiler compounds on the larger installations where it is possible to give it the proper attention. Accurate statistics are not available, but this will probably cover over 50 per cent of the stationary boiler horsepower in this country. For waters which run unsually high in incrusting salts (60 grains per gal. and over) or which run high in sodium

salts, boiler compounds will usually prove superior, as also is the case with waters whose incrusting salts run much lower than the average (less than 8 grains per gal.).

General Summary

For laundries, textile mills, dyeing plants, manufactories of chemicals, extracts, etc., the quality of whose products is lowered by the presence of calcium or magnesium salts, the zeolite water-softener is preferable if the raw water is such that the zeolite water-softener can handle it and if the presence of sodium salts in the water has no injurious effect.

If the water for the above industries cannot be handled by a zeolite water-softener, treatment by the precipitation water-softener will usually prove economical and valuable.

For the manufacture of raw-water ice, the precipitation water-softener is the only satisfactory method of treating.

In larger installations, with an average hard water, which shows no tendency to foaming or priming, for fire-tube boilers, the precipitation water-softener produces the best results.

In smaller installations, or with a low hardness, or an extremely high hardness, for fire-tube boilers, properly prescribed compounds are preferable.

For water-tube boilers of any size and for locomotives boiler compounds usually show best results.

Where high amounts of sodium salts predispose the water to foaming and priming, boiler compounds give best results.

In cases of electrolytic corrosion, the use of a zinc-bearing boiler compound will frequently correct the trouble.

From the above conclusions it is apparent that each type of water purification has a fairly well-defined field in which it is unquestionably *best*. The fields, however, where either of two different methods of treatment would give good results are quite frequently met with, and in these cases individual considerations would decide which of the two methods would be better. If the proposed installation be large enough to justify such action, it would be to the best interests of the user of water to obtain the impartial advice of some reputable consulting engineer.

Hammond Industrial Laboratories,
Hammond, Ind.

The Calcium Requirement of Man

Prof. H. C. Sherman of Columbia University has reported in the *Journal of Biological Chemistry* (vol. 44, pp. 21-7, 1920) a series of figures on the calcium content of various diets, and found that in 227 supposedly typical American diets, while only one was deficient in protein, 37 were deficient in calcium. If all diets furnishing less than 3,000 calories had been increased to that level—i. e., to furnish 3,000 calories—none would have been deficient in protein, but 7 per cent would still be deficient in calcium. Prof. Sherman, who is acting head of the department of chemistry and is one of the leading authorities on food chemistry, emphasizes the importance of increasing the intake of calcium by adding calcium carbonate or phosphate to the diet, or, better still, by increasing the intake of milk and other foods which are rich in lime. Milk has the advantage of increasing the high-grade proteins and of providing the fat-soluble vitamine.

Legal Notes

By Wellington Gustin

Device Having "U. S." as Most Prominent Feature Not Registrable

The Court of Appeals of the District of Columbia has affirmed the decision of the Commissioner of Patents denying to the United States Rubber Co. registration as a trade-mark for shoes the letters "U. S.," written on a disk, with other less conspicuous wording around the border.

The Patent Office had said that the meaning of "U. S." was too clearly established to permit of registration of any mark having that as the most prominent feature. This was agreed to, the decision being based upon section 5 of the trade-mark act, which denies registration to any mark which "consists of or comprises the flag or coat of arms or other insignia of the United States or any simulation thereof, or of any state or municipality or of any foreign nation."

Negligence in Handling of Acids—Care Required to Prevent Injuries to Others

Negligence in the handling of acid is the question presented in the recent decision of the Supreme Court of Rhode Island in the matter of McHugh against Williams & Payton. The latter were manufacturers, using acid in connection with their business. They had a carboy of sulphuric acid stored on the third floor of the building which they occupied. The acid commenced to leak and a quantity went through the floor, falling upon McHugh, who was working for another manufacturing company on the second floor. Because of the severe burns received McHugh brought an action for negligence to recover damages sustained on account of the negligent handling of acid by the defendants. From a judgment against the company an appeal was had and the Supreme Court has reversed the judgment, granting a new trial to the company.

In the court's opinion it appears that, under the Rhode Island workmen's compensation act, had the employee made claim against his employer for compensation and had been paid such compensation he would be barred from bringing an action for negligence against the third party who was responsible for the injury. But this defense was not available in this case.

It was contended for the injured employee that it was the duty of the defendants to use reasonable precaution in placing these acids and in the care of them so that they might not leak upon persons on the floor beneath. The question was presented: What was the duty of the manufacturing company with respect to the care of handling the acid? The court said that its duty was to handle this acid so that it would not injure innocent parties in any other section of the building; and to accomplish this its duty was to use what would be called ordinary care and diligence for the safety of others.

Ordinary Care Defined

Ordinary care was stated to be such care as a person of ordinary prudence exercises under the circumstances of the danger to be apprehended. The greater the danger

the higher the degree of care required to constitute ordinary care, the absence of which is negligence. It is a question of degree only. The kind of care is precisely the same. (52 Atlantic, 1090.)

The trial court held for the employee that, for injuries from a latent defect which cannot be discovered, the defendant is never liable, but that defendant was bound to make such an investigation of the flasks of acid as would lead it absolutely to know that all of them were sound and that there was no crack in them that would permit leakage. But the Supreme Court held this view was erroneous, that the defendants were required to use only ordinary care and diligence in making an investigation as to the condition of the soundness of the flasks, and not make such a particular investigation of them as would lead them absolutely to know that they were sound.

The case was reversed on this erroneous ruling of the lower court. To require the defendants to make such investigation of the flasks as absolutely to know their condition would require them to exercise the highest degree of care under the circumstances, or to be insurers of the condition of the flasks, and this degree of care is not required in the case herein, but only ordinary care under the circumstances and conditions.

Secret Processes and Letters Patent—Nature of the Rights Therein Distinguished

The nature of a patent right for a secret process or invention and one's property right to discoveries undisclosed to the public are considered in a novel case in the New York Supreme Court. A judgment creditor sought to force his debtor to answer questions that would reveal the nature of his claimed invention. Under the New York law a debtor may be examined "concerning his property," and therefore the court said that if the subject matter of the debtor's ideas or claimed invention constituted property rights then the debtor must answer the questions propounded to him.

It appears that the debtor had constructed some models of his ideas but he had not obtained a patent thereon, neither had he made an application for patent, nor has he made his ideas public. In deciding the matter Justice Cropsey gave a clear statement of the law.

It was said that an inventor may assign or transfer his rights to his invention, before making application for a patent, but even where that is done the application for the patent must be signed by the inventor. (94 U. S., 225).

Nature of a Patent

The federal Constitution has conferred upon Congress the power to secure, for a limited time, "to authors and inventors exclusive right to their respective writings and discoveries"; and under this clause Congress has laid down the rules and regulations for granting of letters patent. To obtain a patent the inventor must make application to the Commissioner of Patents, and file with him a description, "in such full, clear, concise and exact terms as to enable any person skilled in the art or science to which it appertains . . . to make, construct, compound and use the same." A patent grants for the term of seventeen years the exclusive right "to make, use and vend the invention or discovery." This exclusive right is a legal monopoly, entirely the creature of statute. At common law there is no exclusive privilege. (9 Supreme Ct., 168.)

The inventor always had at common law, as he now has under the statute, the right to preserve the secret of his inventive genius, and to enjoy the fruits of every legitimate utilization thereof, said the court; but upon permitting his secret to become known, his exclusive rights terminated and his secret became public property. His exclusive right to his invention depended upon his success in guarding his secret.

Now, while a patent confers the right of monopoly and the resulting benefits, it grants to the inventor no right in the conception of his mind, in the secret of his invention that he did not possess before.

Twofold Purpose of Patent Statute

A twofold purpose was said to be accomplished by the statute authorizing the issuance of letters patent. First, it secures to the public forever, after the expiration of the patent, the benefits flowing from the inventor's genius, and, second, it rewards the inventor by giving him, for a limited period, the exclusive privilege of making, using and vending his product. The inventor is rewarded, not for making the discovery, but for disclosing his secret to the public. The disclosure by the inventor is the consideration for the grant of a monopoly by the Government. (30 Cyc., 816.)

In another case, Federal Judge Sanborn said:

"A patent is a contract by which the Government secures to the patentee the exclusive right to vend and use his invention for a few years, in consideration of the fact that he has perfected and described it, and has granted its use to the public forever after." (106 Fed., 693.)

A Secret Process Is Not Property

Therefore, the right possessed under a patent consists in the exclusive privilege or monopoly of making, using and vending the physical product of his invention, and not in the secret hidden in the inventor's mind. When the inventor has made application for patent and has described his invention in "full, clear, concise and exact terms," he has made the required disclosure to the public and is entitled to a patent. This right to patent has been held to be a property right. But before the application is made the right is merely a common-law right to enjoy the fruits of his invention so long as he may be able to keep it secret. Upon discovery being made, the secret inures to the benefit of the public. Therefore, said the court, this right lacks the primary and essentials characteristic of property, which is the capability of being exclusively owned, possessed and used. And before application is made for a patent, the inventor has no property right in the invention which can be subjected to the payment of his debts. But when a patent has been issued, the inventor can be compelled to make an assignment of his property right for the benefit of his creditors.

Right of Inventor to Guard and Preserve His Secret Is Well Established

But it does not follow that an inventor can be compelled to file an application for a patent. The right of the inventor to guard and preserve his secret is as well established as is his right to secure from the Government a monopoly by disclosing his secret, and the inviolability of the common-law right of the inventor to preserve his secret is guarded by federal statute.

Therefore the court held, in the instant case, that the right of an inventor, before he has disclosed his secret, is not property in the general sense requiring the judgment debtor to answer questions revealing the nature of his undisclosed invention.

Motion Pictures in Physical Testing Laboratory

By H. J. French, Met. E.

In studying the properties of boiler plate at various elevated temperatures, including those reached in boiler operation, crude oil distillation, etc., it became desirable to determine the effect of variations in rate of stress application. The factor considered of greatest interest, the limit of proportionality in tension, is generally determined at room temperatures from measurements of elongation under successive increases in load. This procedure, which probably requires the simplest form of apparatus, has likewise been used at elevated

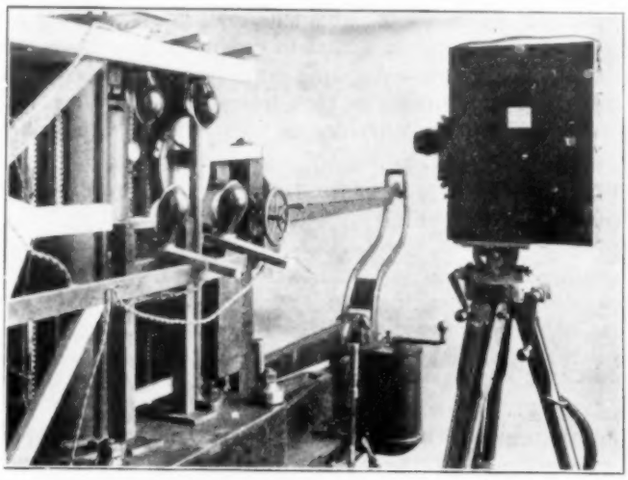


FIG. 1. COMPLETELY ASSEMBLED APPARATUS

temperatures,[1] but is not sufficiently flexible to allow much variation in rate of application of stress or measurement of strain under continuous loading without materially affecting the accuracy of the results obtained. It is here that the motion picture camera finds its application, makes possible the elimination of a complicated mechanism and permits a permanent photographic record of stress and strain to be obtained under continuously increasing load applied at very different rates. Thus its purpose becomes the rapidly repeated and simultaneous photographing of a number of indicators which are always in motion.

Fig. 1 shows the completely assembled apparatus, including camera, used in determination of the limit of proportionality at room and various elevated temperatures. The load-indicating disk is driven by belts and pulleys, as shown in Fig. 2, from the screw operating the rider on the beam of the testing machine, while the two compensating dials measuring deformation are mounted on frames, shown in Fig. 3, which in turn are attached to the test specimen by two yokes. The dials are turned, however, to face in one direction. This arrangement is used to bring these three instruments into nearly one plane and as close together as possible in order that the largest images possible may be obtained on the film, an enlargement of which is shown in part in Fig. 4. The testing machine and camera are operated independently at any reasonable speeds, so that a wide variation in rate of loading and number of photographs of the dials may be obtained.

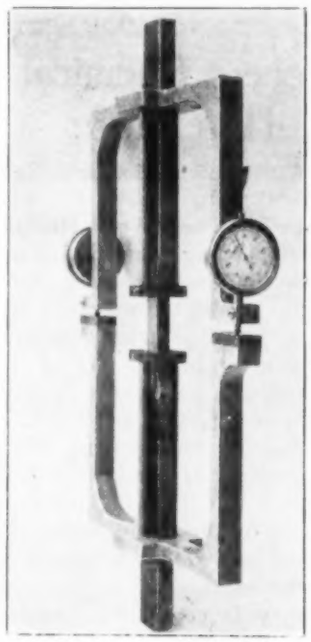


FIG. 3. DEFORMATION-MEASURING DIALS

The test specimen is placed in a tubular electric-resistance furnace and may be loaded at various temperatures. After completion of the test the film is developed and then projected by means of a simple device which allows as much time as desired for obtaining individual readings from any one exposure. From readings so obtained a stress-strain diagram is plotted in the usual manner and the limit of proportionality is obtained. In this case, however, the strain is half the algebraic sum of the deformations recorded by the two compensating dials.

By this method the effect of rate loading on the tensile properties of firebox boiler plate has been studied.

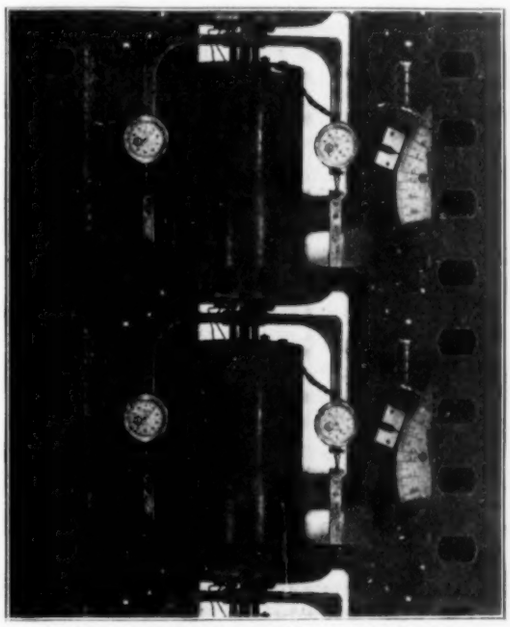


FIG. 4. SECTION OF FILM, ENLARGED

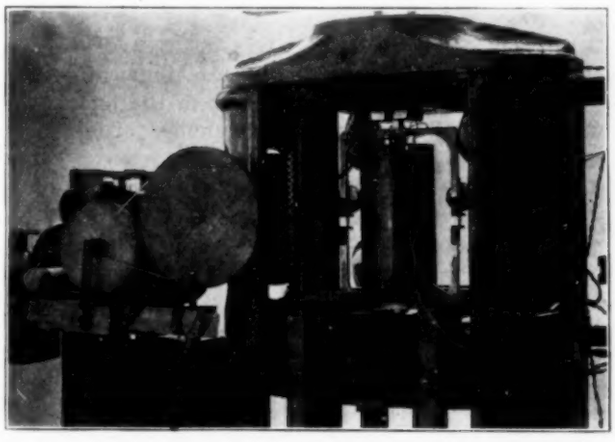


FIG. 2. SHOWING BELTS AND PULLEYS OPERATING LOAD-INDICATING DISK

Published by permission of the Director, Bureau of Standards.

[1] "Tensile Properties of Boiler Plate at Elevated Temperatures," *Mining and Metallurgy*, No. 158, Section 15, February, 1920. CHEM. & MET. ENG., vol. 22, p. 392 (March 3, 1920).

Synopsis of Recent Chemical & Metallurgical Literature

Illuminating and Heating Gas From Wood Distillation.—The industry of manufacturing illuminating and heating gas from wood distillation has made rapid progress in Switzerland during the last few years. The disadvantages of wood gas (presence of great quantities of acetic acid, which is harmful to the life of the pipings, and of carbon dioxide) have been greatly reduced by the use of an improvement in wood distillation which consists in passing the gas through incandescent charcoal. The consumption of charcoal is from 1 to 3 kg. per 100 kg. of wood or 3 to 6 kg. per 100 cu.m. of gas. Tests have shown that by this improvement the following results are obtained as compared with those for a simple distillation of the wood:

The amount of gas produced from a given quantity of wood is nearly doubled.

The carbon dioxide content is reduced 25 per cent.

The calorific value of the gas is reduced 22 per cent.

The heavy hydrocarbon content is reduced about 66 per cent.

The methane content is reduced 50 per cent.

The hydrogen content is increased 80 per cent.

The tar content is decreased 50 per cent.

The acetic acid content is reduced to a practically negligible quantity. The apparatus and pipings are not deteriorated by these small quantities of acetic acid.

The gas produced is much lighter.

The water content of the tar is greatly reduced, thus improving its selling price.—From *Journal für Gasbeleuchtung*. See *Génie Civil*, Nov. 27, 1920, pp. 439-440.

Brass-Casting Practice.—An important research on "The Influence of Gases on High-Grade Brass" was presented before the fall meeting of the British Institute of Metals by T. G. BAMFORD and W. E. BALLARD. Their theoretical studies were supplemented by pouring experiments in a brass foundry and their conclusions were verified in this manner.

It was judged impossible to discover the exact amount of gas present in solid brass by heating it in a vacuum, because the total amount of contained gas would not be evolved and at the same time a considerable amount of zinc would be volatilized. Specially prepared brass was therefore heated at a uniform rate in a tight tube containing a pure gas and the absorption at different temperatures inferred from the change in pressure. Comparing the curve thus plotted with a blank run with no metal, it was found that CO_2 was apparently not absorbed by brass, CO was absorbed to a slight extent, and H_2 showed a fairly large and regular absorption. Sulphur dioxide was absorbed in large quantities between 300 and 1,020 deg. C., at which temperature absorption ceases and an evolution of gas commences, becoming more rapid up to 1,100 deg. C. A marked chemical reaction takes place, producing heavy scale, accompanied by sulphidation, dezincification and the formation of blowholes. No results were possible with methane due to complex reactions accompanied by carbon deposition.

Experiments were then devised and executed to measure the rate of reaction between SO_2 and brass, and the results were interpreted to mean that under the small partial pressure of SO_2 existing in any furnace atmosphere this gas could not be absorbed by brass at a correct pouring temperature, but would be actually eliminated from the metal.

This implies that the metal must be hot enough to remain fluid in the mold for a few minutes after pouring, and is one reason why brass cannot be poured at too low a temperature.

Experiments to measure the solubility of H_2 in brass were then undertaken, despite the apparent difficulty. Hydrogen-free brass was finally prepared by melting the metal in an atmosphere of CO_2, bubbling this gas through the metal for about half an hour, pouring and cooling the metal in a carbon dioxide atmosphere. An ingenious experimental apparatus was then devised for bringing the brass to the desired temperature in a neutral atmosphere, replacing this with an atmosphere of hydrogen without involving heavy zinc losses, and the measurement of the weight of the hydrogen absorbed. The notable and important feature of these experiments is that the solubility determinations were made without subjecting the brass to any pressures differing largely from that of one atmosphere. The results are shown in Table I.

TABLE I. 70:30 BRASS (71.10 PER CENT COPPER)

Temperature, Deg. C.	Solubility, Mg. per 100 g.
870	11.0
820	6.9
725	6.7
540	2.5
30	nil
850	3.3
750	2.7
30	nil

Several different investigators agree that H_2 is soluble in Cu at 600 deg. C., with a solubility rapidly increasing with temperature, reaching 0.3 mg. in 100 g. at 920 deg. C. Little information is available on H_2 and Zn, however, so experiments tabulated in Table II were performed.

TABLE II. BRUNNER MOND ZINC (CAST IN CO_2)

Temperature, Deg. C.	Solubility, Mg. per 100 g.
750	1.3
600	3.5
300	4.8

Evidently 70:30 brass can absorb much more H_2 than can either of its constituents.

Having determined the fact that hydrogen was absorbed in large quantities, it was important to discover how it could be extracted from the metal. This was done by heating weighed samples of brass in a stream of dry carbon dioxide to oxidize any hydrogen in the sample and then collecting and weighing the water formed in the reaction.

It would appear from the results that a large proportion of the hydrogen retained in the brass is easily removed by heating at 600 deg. C. or above. The major portion of the hydrogen absorbed during heating is usually retained on cooling.

Brass can evidently either adsorb large quantities on its surface, or large quantities can actually pass into the metal.

In the former case, clearly, such adsorbed gas could

not be responsible for internal unsoundness, and in the latter case, since the H_2 could diffuse through the metal, it could hardly develop sufficient internal pressure to be responsible for blowholes. Such an argument does not apply in the case of SO_2, which in connection with an unsuitable pouring temperature might be responsible for unsoundness.

Investigation was therefore carried out on the relationship existing between the casting and pouring temperatures and the qualities of brass casting. Billets were cast in a brass foundry, observing the temperatures of casting and examining the condition of the billets at the end. Furthermore, a special furnace was designed and built with the object of obtaining a positive answer to the question as to whether any particular furnace gas would have a deleterious effect upon the quality of brass castings, provided the metal was poured at the correct temperature.

These practical experiments verified the following theoretical conclusions completely:

1. In ordinary foundry practice, using a coke-fired natural-draft wind furnace, it is impossible to impair seriously the mechanical properties of the casting by overheating.

2. Cooling the metal to within 40 deg. C. of the liquidus will certainly ruin the mechanical properties of high-grade brass which has been melted in ordinary furnace atmospheres, and will probably render the casting porous.

3. In casting tubes a higher temperature is needed than when casting solid ingots, and it is not advisable to cast 70:29:1 tubes below 1,150 deg. C.

4. Exceptionally prolonged periods of heating of the metal in the furnace do not impair the mechanical properties of the resulting casting, but of course are to be deplored for commercial reasons, on account of the consequential high zinc losses.

5. The furnace treatment is not a deciding factor in influencing the quality of the casting, but the pouring temperature is the notable factor.

6. Unsoundness is usually confined to the upper portion of a casting.

Carbide in Quenched and Tempered Steels.—In the thirty-eighth report of the Japanese Iron and Steel Institute SEIZO SAITO determines by means of magnetic and X-ray analysis that it is immaterial whether one says that cementite or carbon is dissolved in iron to form austenite, since both these phrases refer to the same atomic configuration. If free carbon does dissolve in iron when the mass is heated above the transformation it is reprecipitated as cementite. When tempering a quenched steel at about 300 deg. C. cementite is first set free, but owing to the extreme fineness of the particles the greater part readily decomposes. (Eutectoid steel first separates cementite on tempering at 130, and precipitation is complete at 360 deg.) Honda had previously found that the amount of precipitated cementite reaches an asymptotic value at about 400 deg. C., further heating to 700 not appreciably increasing its quantity; the amount is less than the value before quenching, possibly by a value equal to that which decomposes when extremely finely divided. Coagulated cementite forming a comparatively large grain (pearlite) or massive cementite in hypereutectoid steels does not decompose below A_1 to any extent, but in the latter case free cementite does partly decompose above Ac_1.

Recent Chemical & Metallurgical Patents

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Ammonia-Soda Process. — In the usual ammonia-soda process the mother liquor obtained by filtering out the sodium bicarbonate contains small proportions of sodium and ammonium bicarbonates and large proportions of sodium and ammonium chlorides. This liquor is treated with lime in the ammonia stills for the recovery of ammonia. Nearly one-half of the original sodium chloride is lost in the calcium chloride brine, so that the process cannot be worked commercially except at places where salt can be very cheaply obtained. According to a modification proposed by TORANOSKE NISHIGAWA of Tokyo, Japan, more sodium chloride is added to the filtrate after the separation of sodium bicarbonate and ammonium chloride is precipitated by cooling to below 5 deg. C. Prior to cooling, sufficient ammonia is added to the liquor to convert the small proportion of bicarbonates into normal carbonates. This ammonia is prepared synthetically from the gas from the scrubbers and carbonators, which is almost pure nitrogen. Either the cyanamide or the Haber process may be used. After filtering off ammonium chloride, the mother liquor (containing ammonium carbonate, sodium chloride and some ammonium chloride) is returned to the absorbers to form ammoniacal brine. (1,359,097; Nov. 16, 1920.)

Phosphoric Acid.—FRANK S. WASHBURN of Rye, N. Y., has improved the process for the production of phosphoric acid from phosphate rock described in his earlier patents—1,047,864, Dec. 17, 1912, and 1,100,639, June 14, 1914. An electric furnace is charged with a mixture of phosphate rock and silica and the necessary amount of carbon is fed in from a hopper in the top of the furnace. Further quantities of phosphate and silica are fed from a bin to a rotary kiln and then pass through a hearth furnace before entering the electric furnace through a side opening. The hot gases and vapors from the electric furnace pass through the hearth furnace and kiln in the opposite direction and thus serve to preheat the charge so that maximum thermal efficiency is obtained. (1,359,211; assigned to the American Cyanamid Co.; Nov. 16, 1920.)

Anhydrous Magnesium Chloride. — Needle crystals of magnesium chloride are partly dehydrated by the use of large volumes of heated air until the melting point of the salt is raised above 250 deg. C. The material is then placed in a retort and a current of dry HCl is passed through while the temperature is slowly raised from 150 to 650 deg. C. The product is 98 to 99 per cent $MgCl_2$. (1,359,652; EDGAR A. ASHCROFT of London, England; Nov. 23, 1920.)

Magnesium.—Metallic magnesium is prepared from anhydrous magnesium chloride, made according to the process described in U.S.P. 1,359,652, by the use of a twin cell electrolytic apparatus. In the primary cell the anodes are of graphite, the cathode is a molten magnesium:lead alloy and the electrolyte consists of fused

anhydrous magnesium chloride. Magnesium:lead alloy from the primary cell forms the anode of the secondary cell and the metallic magnesium which collects at the iron cathodes floats on the surface of the fused $MgCl_2$ electrolyte and is removed periodically. A current efficiency of 90 to 95 per cent is claimed. The primary cell voltage varies from 4 to 6 volts; that of the secondary cell from 1 to 2.5 volts. The current density is such that the surplus energy maintains the contents of the cells in fusion—that is, at about 750 deg. C. When magnesium alloys are made, only the primary cell is used. The chlorine gas evolved at the primary cell is absorbed in a water emulsion of lightly calcined magnesite, forming magnesium chlorate and magnesium chloride in the molecular proportions of 1:5. The chloride is crystallized, dehydrated and used as electrolyte. The chlorate may be used as such or it may be converted into potassium chlorate and magnesium chloride. (1,359,653 and 1,359,654; EDGAR A. ASHCROFT of London, England; Nov. 23, 1920.)

Magnesium Chloride. — Slaked dolomitic lime is treated simultaneously or successively with an amount of CO_2 equivalent to the calcium in the lime and an amount of SO_2 equivalent to the magnesium content of the lime:

$$Ca(OH)_2.Mg(OH)_2 + SO_2 + CO_2 = CaCO_3 + MgSO_3 + 2H_2O$$

Calcium chloride is then added to convert the magnesium sulphite into magnesium chloride:

$$MgSO_3 + CaCl_2 = CaSO_3 + MgCl_2$$

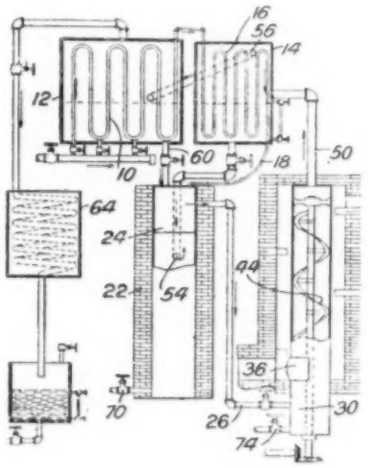
The precipitated carbonate and sulphite of calcium are removed by filtration. (1,359,782; EDWIN O. BARSTOW of Midland, Mich., assignor to the Dow Chemical Co.; Nov. 23, 1920.)

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Recovering Tin and Zinc From Scrap.—Zinc chloride, palmitin and tin are recovered from the scruff from tinning pots. The scruff is crushed to pieces about ¼ in. in diameter, agitated in a tank with about one-fifth as much water below 60 deg. F. until the zinc-chloride solution obtained has a specific gravity of 1.3, when it is drawn off and filtered in a filter press. The remaining sludge in the tank contains palmitine, which term includes palmitin and palmitic acid, tin, tin oxide and a small proportion of chloride of zinc and is ground with water to a paste and screened to remove the heavier particles of tin. "Tin soap," which consists of tin oxide and palmitine, and a proportion of the lighter particles of tin are also separated in the screening operation and are then agitated in a vessel when the tin sinks and the supernatant palmitine and tin oxide are filtered to remove water, treated with sufficient hydrochloric acid to dissolve any zinc and tin oxychlorides, filtered, dried and distilled. The distillate contains a mixture of palmitin and oil. (Br. Pat. 151,374. G. H. CLEGG, Cardiff; Dec. 8, 1920.)

Cracking Hydrocarbons. — In decomposing heavy hydrocarbon oils to yield lighter oils by heating them under pressure, the free carbon which is formed is continuously removed. The oil is heated in a furnace-heated vertical still 30, containing a rotary scraper 44 and is kept normally full of oil. Vapors and oil from the still pass up a pipe 50 to a separating chamber 14, from which the oil passes by a pipe 54 to an insulated vessel 22 in which the oil rises slowly upward and passes through a screen 24. The suspended carbon deposits in the vessel or is retained by the screen. The oil returns to the still by a pipe 26. The vapors may be passed from the chamber 14 by a pipe 56 to a chamber 12 in which the temperature is controlled by passing the oil supply through a greater or less length of the coil 10. The heavy oils condensed in chamber 12 are passed by a pipe 60 into the vessel 22 and the vapors pass to a condenser 64. The oil supply may be pre-



heated by passage through the coil 10 and a coil 16 in chamber 14 and is admitted to the vessel 22 by a pipe 18. The bases of the vessel 22 and the still 30 are fitted with blow-off cocks 70, 74 to remove deposited carbon. The circulation of the oil among the still 30, the separator 14, and the carbon-removing vessel 22 may be assisted by a pump. The pressure within the circuit is maintained between 60 and 120 lb. per sq.in., and the temperature between 370 and 450 deg. C. (Br. Pat. 151,925; not yet accepted; R. D. GEORGE, Boulder, Col.; Dec. 15, 1920.)

Washing Crystals.—Crystals deposited from a solution containing more than one salt are freed from mother liquor in a centrifugal machine, the process being completed by treating the crystals immediately the bulk of the mother liquor has been removed with water in a state of fine subdivision, either as spray or wet steam, so that no dry air can enter the mass until all the mother liquid has been removed. The crystals are preferably taken from the evaporator and treated at the temperature of their formation, the steam being introduced at a temperature suitable to bring about this result. A centrifugal machine which can discharge the crystals without stopping is preferably used. The process is described in connection with freeing crystals of sodium carbonate from a liquid containing common salt. (Br. Pat. 152,041, J. T. WINDRAM, Johannesburg, S. A.; Dec. 15, 1920.)

Dyes.—The products obtained by treating the sodium or ammonium salts of nitrated diphenylamine compounds with an alkaline cyanide in aqueous solution dye wool brown to purple shades. The diphenylamine compounds should yield water-soluble alkaline salts; the examples provided being hexanitrodiphenylamine, tetranitrothiooxydiphenylamine; 2:4-dinitrodiphenylamine-*p*-sulphonic acid and 2:4-dinitrodiphenylamine *m*-sulphonic acid. (Br. Pat. 151,868, BRITISH DYESTUFFS CORPORATION and J. TURNER, London, and L. G. BADIER, Hudersfield; Dec. 15, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Fixed Nitrogen Corporation Bill Passes Senate

By a vote of 34 to 29, the bill providing for the creation of the United States Fixed Nitrogen Corporation was passed by the Senate Jan. 14 after it had been extensively amended. The chief responsibilities were vested in the President and the handling of the business end of the organization was lodged in the Secretary of the Treasury. Originally the bill provided for vesting most of the responsibility in the Secretary of War, who also was to be in complete charge of operations.

While the passage of the bill by the Senate is regarded as a victory for those favoring it, there is much doubt whether it will be passed by the House. If the bill can be brought to a vote there, it probably will pass, but under the rules it will be difficult to bring it before the House without having the consent of the majority leaders, and it is doubtful if that can be obtained.

The debate on the bill was particularly acrimonious. Senators Wadsworth, Lenroot, Poindexter and others were accused of filibustering against the measure. Although this charge was denied, it is evident that the opponents of the bill left little unsaid in regard to it. For that matter, however, the proponents of the bill occupied much time with their arguments.

The opposition to the administration of the corporation by the War Department was led by Senator Wadsworth, of New York, chairman of the Committee on Military Affairs. In that connection he said: "I think the Secretary of War should not be burdened with more civil jurisdiction. We have piled him with it in recent years. This bill, as drafted, would make him the responsible head for the carrying on of a great commercial business, the manufacture and sale of fertilizer. Military men are suggested as officers of this commercial corporation. Army officers are not trained business men. Soldiers ought not be assigned to work of this character.

"This enterprise should be put under the Treasury Department and business men. The Treasury Department is the business end of the Government."

The desires of Senator Wadsworth in that connection were adopted finally without objection.

An important amendment embodied in the bill just before it was passed provided that:

"The corporation shall be conducted under the supervision and control of a board of directors consisting of not less than five nor more than seven members, to be appointed by the President, by and with the advice and consent of the Senate."

The provision authorizing appointment of army officers as directors was stricken out. The bill was also amended by denying condemnation power to the corporation.

During the discussion of the bill Senator Smoot charged that the principal purpose behind it was not national defense or the manufacture of fertilizer, but the harnessing of a water power at Government expense for the use of the industries and the utilities in the territory tributary to Muscle Shoals.

Sheffield Scientific School Lecture Course for Graduate Students

The following program of lectures at Sheffield Scientific School, Yale University, by well-known leaders in the cheimcal world, has been arranged so as to give the graduate students of organic chemistry a broader vision of its application in the industries and the inspiration, which comes by contact with such men, to seek further the truths revealed by research:

1. Prof. R. H. McKee, professor of chemical engineering, Columbia University, New York City.
2. Prof. E. V. McCollum, professor in department of chemical hygiene, Johns Hopkins University, Baltimore, Md.
3. Prof. H. N. Holmes, chairman of department of chemistry, Oberlin College, Oberlin, Ohio.
4. Dr. David Wesson, technical director, Southern Cotton Oil Co., Savannah, Ga.
5. Dr. M. L. Crossley, research director, Calco Chemical Co., Bound Brook, N. J.
6. Dr. P. A. Levene, chemist, Rockefeller Institute for Medical Research, New York City.

The first speaker, Prof. McKee, will deliver two lectures as follows: Jan. 20 at 8:15 p.m., on "Tendencies in Chemical Engineering Education"; Jan. 21 at 9 a.m., on "Plant Problems Falling to a Chemical Engineer."

Stamford Chemical Society Elects Officers

The officers elected to take charge of the affairs of the Stamford, Conn., Chemical Society are: President, G. C. Givens; vice-president, S. D. Shipley; secretary, F. B. Wilson; treasurer, R. H. Stevens; director, E. H. Smith.

At the next regular meeting on Jan. 24, Dr. Allen Rogers of Pratt Institute will give an illustrated lecture on "The Utilization of the Shark."

Fellowships Open at Urbana

Sixteen research graduate assistants are maintained by the Engineering Experiment Station, University of Illinois, some of which are now open, each of which carries a stipend of $600 plus fees. Appointments are for two years, and require not more than half the time at the problem assigned, the remainder being available for graduate study. Further information may be had from Dean C. R. Richards, Urbana, Ill.

Meeting of the Syracuse Section of the A.C.S.

The Syracuse Section of the American Chemical Society held a very interesting meeting on Jan. 7. Dr. C. G. Derick of the National Aniline & Chemical Co., Buffalo, delivered a talk on "Methods of Attacking a Research Problem."

Western Canada Pulp & Paper Co. Enlarges

The Western Canada Pulp & Paper Co., which recently took over the Rainy River Co.'s plant at Port Mellon, B. C., has reconstructed and enlarged the plant and is adding new machinery. The enlarged plant will have a capacity of forty tons of pulp per day.

Metric System Bill Introduced

A bill providing for the compulsory use of the metric system as the single standard of weights and measures in the United States has been introduced in the Senate by Senator Frelinghuysen, of New Jersey. The bill was introduced at the request of advocates of the metric system. Senator Frelinghuysen explains that the introduction of the bill by him does not necessarily carry with it any support on his part for the measure, but he sees no reason why the measure should not be introduced so that members of Congress might acquaint themselves with its purport.

Ten years after the passage of this bill the weights and measures of the metric system would be the single standard for the sale of goods and for computing transportation charges and wages. In order to accustom the public to the new system, all goods in package form which are required to be marked in terms of weight or measure must use the metric system beginning two years after the passage of the bill. From the second to the tenth year the customary units may be retained in addition to the metric, if desired. After four years, weighing and measuring devices shall be manufactured in accordance with the metric system.

Certain exceptions are noted in section 12 as follows:

Sec. 12. That nothing in this act shall be understood or construed as applying to—

(1) Any contract made before the date at which the provisions of this act take effect;

(2) The construction or use in the arts, manufacture or industry of any specification or drawing, tool, machine or other appliance or implement designed, constructed or graduated in any desired system;

(3) Goods, wares or merchandise intended for sale in any foreign country, but if such goods, wares or merchandise are eventually sold for domestic use or consumption then this clause shall not exempt them from the application of any of the provisions of this act.

New Jersey Chemical Society Holds Its January, 1921, Meeting

At the regular monthly meeting of the New Jersey Chemical Society held in Newark, Monday evening, Jan. 10, further growth of the society was manifested by the election of thirty-one new members, thereby bringing the total membership to 576.

Dr. M. C. Whittaker, vice-president of the U. S. Industrial Alcohol Co., gave a very instructive address on "Chemical Organization and Management." He said that three factors—the plant, the process and organization—had to be considered in dealing with this problem, and that the organization factor was the most important. The necessity of a one-man power supplemented by disciplined and dependable co-ordinating units whose work accrues to the employer's benefit, to the successful development of an organization, was strongly emphasized.

Of the various problems pertaining to the smooth functioning of the units the following heads were considered: Misfits in Organization, Intelligence vs. Brawn, Doers vs. Excusers, Materialists vs. Dreamers. Emphasis was laid upon the need of studying the individual man so as to place him in a position where he could utilize his natural ability in the most efficient manner.

Various types of organizations were described and discussed. Among these were dry rot, which required a surgical operation as a remedy; young organizations, characterized by what Dr. Whittaker called "the admistrative double pass," where everybody passes his responsibility on to some one else; the all bosses, with no one to do the work; and the lop-sided organization, where there exist petty jealousies and a lack of proper balance between the technical and practical sides of the work.

Dr. Whittaker said that a true test of a successfully operating organization was when all the units were functioning smoothly, and the individuals were all working in harmony and in such a way that the man at the head could devote his energy to the problems of development instead of spending most of his time keeping the machinery going.

C. O. Chan, B. S., of the China Commercial Co., Ltd., gave a short résumé of the economic and political conditions existing in China. He said that due to lack of transportation and banking facilities large-scale production was impossible. Although there was a great deal of money in China, it was so distributed and disorganized as to prohibit its use in large amounts which are necessary for the development of industry by modern business methods. The political situation was characterized as a mixture of ancient Chinese traditions and a copy of European and American customs.

Three fundamental political tendencies have gradually been developed since the beginning of the Chinese Republic. They are the vigorous reform tendency represented by Dr. Yat-sen, Dr. Wu Ting-fang and the common people; the progressive tendency led by the scholar Liang Chao Chu advocating moderate reform, and the reactionary tendency represented by the Monarchist party. Besides these, there are two other groups representing powerful interests and privileges, the military, or Pei Yang, group and the Communication, or Chiaotung, group.

The Monarchist party has become insignificant and is on the decline; the leader of the Progressive party, although exerting great influence by his pen, lacks strong executive ability and consequently the party has never been able to stand on its own feet and is dependent upon whatever other party is in power. The result is that the Military and Communication groups control the situation in northern China, where they are the strongest, and the common people in the southern provinces, where they predominate.

Both the economic and the political situations were depicted so as to give the American manufacturer an idea of the problems which confront him in doing business with the Orient. China, with its 400,000,000 population, represents a tremendous potential buying power and is a great market for manufactured chemicals. In turn she is rich in raw materials such as vegetable oils, camphor, coal, copper, gold, iron ore, antimony and tungsten. Mr. Chan expressed the hope that the United States might grasp this great opportunity to develop a chemical trade which would be of such immense benefit to both parties.

C.W.S. Service School Opens

The Service School of the Chemical Warfare Service at Edgewood Arsenal opened on Jan. 10. The purpose of the school is to develop officers for the command of Chemical Warfare Service troops in the field and to act on the staff of division, corps and army commanders.

In addition to instructing these officers in the specific military problems arising in connection with the use of gas, the men will be schooled in the fundamental chemical problems involved and the chemical properties of the various gases.

The Crocker-McElwain Plan to Help Employees

The Crocker-McElwain Co. and the Chemical Manufacturing Paper Co. have recently announced a plan for the relief of the hazard of unemployment so far as their employees of more than five years service are concerned. Their idea is to place any employee of more than five years service on the salary list. At such times as the mills may be closed the employee will receive salary, and in turn he obligates himself to do other work about the mill than his ordinary position would call for. The nature of this work is to be agreed upon by the employee and his immediate superior. When the mill is operating the workman will receive either salary or the regular wage scale, depending on which amounts to the larger sum per week. This contract may be terminated by either party on giving four weeks notice.

Evaporation Plant to Be Erected at Soda Lake

The Sodium Mining & Products Co. will erect a new evaporation plant at Soda Lake, near Seventy-Mile House, on the old Cariboo stage road. The company has appealed to the Provincial Government, which owns and operates the Pacific Great Eastern Ry., for a spur-line to the plant. Soda Lake is situated 3,700 ft. above sea level, has an area of 100 acres and a sodium carbonate content of 6 per cent; but this, of course, must vary with the seasons of the year. There are a number of smaller lakes in the vicinity that contain about the same amount of sodium carbonate. In 1918 a small evaporating plant, capable of producing two to three tons of crystals daily, was erected.

Book Reviews

PRIESTLY IN AMERICA. 1794-1804. By *Edgar F. Smith*. Philadelphia: P. Blackiston's Son & Co. 1920. 12mo. pp. 173.

In this little book Dr. Smith has achieved a work of rare literary merit. We knew already that Priestly was an English Unitarian minister, that he discovered oxygen, that for the faith that was in him he was mobbed and persecuted so that he fled to America; that to the end of his days he held to the phlogiston theory, and that he died and was buried at Northumberland, Pa.

Then, when we have read the book through, we feel as though we had at least a bowing acquaintance with the old gentleman, who was sixty-one years old when he came here and seventy-one when he died. We get also a sense of his importance as an international character. He lived in very interesting days, at a time when men thought seriously. He was a man of great influence in England, as is shown by a contemporary caricature on the walls of the Chemists' Club which depicts him as aiding in the service of a troublesome feast for King George IV. We get a sense of his importance as a person when we read the addresses presented to him on his arrival in New York, and again on his advent in Philadelphia. We learn of his scholarship and of his familiarity with and practice of the graces of life, by reading his replies. Intense democrat that he was, he remained to the end of his days a person of quality and distinction. He was never commonplace or vulgar.

He began with a pleasant acquaintance with John Adams, but he had no patience with his administration as President, whereas his admiration for Thomas Jefferson and his hearty friendship with him was of lifelong endurance.

It does not appear that he ever left the State of Pennsylvania after he settled down there and during the years of his life in this country he made but four visits to Philadelphia. He declined a professorship in chemistry there. He was maliciously attacked by persons of the same habit of mind as those who had persecuted him in England, but it did not worry him. He was always ambitious to see a college started at Northumberland, where has was content to live. A Mr. Bakewell met him in 1795, and found him "a man rather below the middle size, straight and plain, wearing his own hair; and in his countenance, though you might discern the philosopher, yet it beamed with so much simplicity and freedom as made him very easy of access." Another said of him: "The doctor enjoys a game at whist; and although he never hazards a farthing, is highly diverted with playing good cards, but never ruffled by bad ones."

Very gently Dr. Smith leads us to the Northumberland home when his youngest son Harry, who lived with him and was clearing 300 acres of land, went the way of all flesh. It was among his greatest delights merely to be with this eighteen-year-old boy. No attempt is made to lay bare the old man's heart before us. Indeed, little is said, but that little is very subtle, and it carries us into sincere sympathy with him.

Sir Oliver Lodge has said of Priestly that "his experiments were admirable, but his perceptions of their theoretical relations were entirely inadequate and, as we think now, quite erroneous. . . . In theory he had no instinct for guessing right . . . he may also be said to have had a predilection for the wrong end." This is borne upon us as we read of his chemical activities. There is no doubt in his perseverance in what he held to be right. All his life he held to the phlogiston theory and fought for it. It guided his experiments and led him constantly astray. It effectively spoiled most of his writings on chemistry. Indeed phlogiston seemed to be no less than an obsession with him. It had this value, however, that his championship of the cause brought out such forceful and competent opposition from his fellow chemists in America that it requires no stretch of the imagination to say that the ghost of phlogiston was finally and effectively laid for all time by James Woodhouse and his colleagues.

Much of his attention was given to the preparation of his Church History and his Notes on the Scriptures, which, Dr. Smith says, contain an immense fund of worth-while information and knowledge. The infirmities of age weakened his body, but left his mind clear and vigorous until, in the very act of correcting proof of his Church History, he quietly breathed his last on Feb. 6, 1804.

The book is a rare tribute to a great chemist and one of the leaders of the thought of his day. And it is another token of Dr. Smith's rare gift in literary art. We commend it heartily to our readers.

ELLWOOD HENDRICK.

* * *

"THE MAKING, SHAPING, AND TREATING OF STEEL." By *J. M. Camp* and *C. B. Francis*. Second Edition. Published by the Carnegie Steel Co., Pittsburgh, Pa.* Price $5, cash with order.

This excellent book is unique in its scope, its accuracy, and its lucidity. Those who work with rolled and semi-finished steel products or buy or sell them in quantity, who by curiosity or ambition attempt to learn something about the industry, may rely upon it to give them the maximum amount of information which can be conveyed without entering the realm of the specialist and employing his oft-unintelligible language.

Heretofore the literature (other than that contained in current periodicals) might be classed in three groups. First is a number of elementary books, written in simple language but unfortunately descriptive of a localized industry or a particular branch of the steel business—in other words, either provincial or specialized—and nearly always out of date and out of print. Next is a number of brief texts designed to give college students an outline view of iron and steel—covering more recent practice, but ordinarily assuming a familiarity with elementary chemistry

*Obtainable by non-employees by addressing the Bureau of Instruction, Carnegie Steel Co., direct. Not sold by or through book stores or dealers.

and physics on the part of the reader. Finally there is a certain small group of really excellent books treating some phase of the industry in an exhaustive manner—books of reference and instruction for the engineer in the industry, and requiring advanced knowledge of its technology on the part of the readers. In this group Harbord and Hall's volumes are the only ones in English which attempt to cover the whole field. Unfortunately these are rather expensive, and are largely occupied by British and Continental practice.

Having these conditions in mind, it is not surprising that the non-technical student found much to discourage him in his search for information, and the expert was hard put to suggest books which were not specialized and yet descriptive of modern operations. This new volume by Messrs. Camp and Francis will supply this need and thus fill the great gap. It is not too much to think that it will also become very popular in engineering colleges offering courses in metallurgy. Doubtless numerous engineers and foremen will find it of considerable service in giving notes on many milling operations not ordinarily described even in the most pretentious works, and in providing clear outlines of related phases of their industry.

It should be easily adopted as a text-book since the volume in fact is "the outcome of several years' experience in attempting to teach the metallurgy of steel to salesmen and other non-technical employees." A passage describing an operation which later turned out to be but hazily comprehended could then be recast into more intelligible language. Many pages bear marks of such painstaking revision—notably in the descriptions of the chemistry of the iron- and steel-making processes. While an intelligent reader can easily grasp the chemistry involving the combustion of coke to CO and CO_2, a clear comprehension of the reversible reactions which occur whenever the $C:CO:CO_2$ equilibrium is disturbed is not so easy, nor is it apparent at first sight how ores can be reduced, iron carburized and even reoxidized by the same two gases. Lacking any analogous phenomena in everyday life, the student will have extreme difficulty in understanding the reactions between slag and metal in an electric or open-hearth furnace—in fact one could venture the assertion that there are few operators or even advanced investigators who have a workable familiarity with the balanced reactions occurring in steel-making processes.

Naturally the treatment of these matters cannot be rigorous and it is a difficult matter to balance lucidity against chance of misinterpretation or minor inaccuracies, but the reviewer has nothing but praise for the result. He can testify to the great pedagogical value of the conception of iron as the oxygen carrier in the purification stages, even though it is debatable whether the oxide actually exists as a definite and separate entity, and even though all oxides appear to be nearly if not quite insoluble in molten and solid iron.

A good discussion of sulphur in the open-hearth is given on p. 236, especially the gain in sulphur from impure fuel. In this connection, one important limitation to the book should be noted—and would probably be instinctively taken by the expert, and that is that the practice described is Steel Corporation practice. While its plants are numerous and its operations tremendous, there are certain very excellent and useful metallurgical methods in daily operation elsewhere which are not practiced by that corporation. It is consequently a record of contemporary practice in the corporation (especially the Carnegie Steel Co.) and when the authors say (p. 181) that "the removal of sulphur in the mixer at all times is so small as to be of minor importance" the sophisticated reader will immediately visualize low-manganese pig iron from the corporation's blast furnaces, and perhaps at the same instant remember the excellent sulphur elimination between blast-furnace and open-hearth described last year by Wheaton of the Bethlehem Steel Co. Hence also the failure to mention the excellent acid open-hearth process, and various other processes in constant use here and elsewhere—puddling, basic bessemer, cementation, and crucible melting. Doubtless for the same reason forging and heat-treating practice is confined to a short chapter (pp. 508-515), while steel and iron foundry practice and the production of malleable iron are not mentioned.

Is it possible to assume, conversely, that the scant mention given to heat control is due to a widespread disuse of pyrometers in Steel Corporation plants?

On the other hand, perhaps the fifty pages given to the electric furnace and its operation are due to the necessity of introducing the reader to the elementary electrical facts, and for the benefit of their salesmen selling specialties such as highly refined, multiplex, and alloy steels, rather than an appraisal of the relative importance of the process from a tonnage basis, either present or prospective.

These deficiencies in scope are compensated by good discussions on many lines. First there is a series of chapters containing very clear outlines of elementary physics and chemistry, refractories, ores, fluxes and slags. Especially notable is the chapter on fuels for its full discussion of the use of pulverized fuel in open-hearth furnaces, the authors concluding a very favorable appraisal with the suggestion that while its use was "still experimental," powdered fuel gives promise to replace gas in the steel plant. A description of the installations at Sharon, Clairton and Homestead works is included.

Perusal of the chapters on the constitution, heat-treatment and composition of steel at the end of the book should do much to dispel the idea that metallography is a highly complex and difficult subject largely of academic interest. Praise is also due the 200 pages of Part II on the shaping of steel. They contain the most comprehensive description of all modern rolling mill operations known to the reviewer. Many topics are covered not to be expected in elementary books, notably roll design for rails, the shaping of rail joints, rolling of tires and car wheels, inspection of finished material for defects, and the scheduling of orders.

The book itself is bound in limp leather, and can be carried around in one's pocket despite its 600-odd pages. Unfortunately the thin paper does not reproduce half-tones well—in fact, the authors have been too sparing in the use of line drawings to illustrate the early portions of their book covering furnace design and practice. Their descriptions are quite full, and in fact the text is a veritable glossary of terms; but these descriptions would be much enhanced by appropriate sketches. The second half of the book does not suffer in this respect.

From an instructional standpoint, the worst fault in the book results from its avowed aim: to describe things as the authors found them and why they are so, rather than to discuss what they should be. It might be argued that in educating a steel salesman, it would not be well to tell him that steel might be made better than it is today. The present reviewer apprehends more harm than advantage in half-truths, and directs his greatest criticism at the resulting sentiment—sometimes definitely stated—that we are at the crest of excellence. Thus the statement on p. 130 that the "blast-furnace plant is just approaching the uniformity of perfection" is bad news for the blast-furnace man, condemning him to a lifetime of merely doing what has been done before! Again "the old-time method of charging by hand having been entirely superseded by automatic charging" is somewhat overoptimistic, since hand-fired furnaces of the Shoenberger works may be seen when standing at a window in the Carnegie Building. A strong plea is made in the book against the "ridiculous" insistence upon low limits for sulphur and phosphorus, since "it is becoming increasingly difficult to keep the sulphur content below 0.04 per cent," and when the evidence (Unger's tests probably, made by adding sulphur and phosphorus when pouring an ingot) "points so strongly to 0.10 per cent as a limit that may be made to serve as well, for many purposes, at least."

Some things get to be accepted as facts by the majority of men if they are repeated often enough. It would be unfortunate if young engineers, and doubly unfortunate to the Steel Corporation if its staff were in this way to acquire the idea that further progress in steel making is not to be expected, and that 0.10 per cent sulphur and phosphorus are to be accepted without suspicion.

E. E. THUM.

Personal

Dr. C. L. ALSBERG, retiring president of the Washington Academy of Sciences, will deliver his presidential address on "The Relation of Chemical Structure to Physiological Action" before the joint meeting of the Washington Academy and the Chemical Society of Washington on Thursday, Jan. 20.

Dr. L. H. BAEKELAND is on a business trip to Denver, San Francisco and other Western cities.

KENNETH E. BAIRD, formerly chemist at the Pittsburgh byproduct coke plant of the Jones & Laughlin Steel Co., Pittsburgh, Pa., is now chief chemist of the Donner Union Coke Corporation, Buffalo, N. Y.

J. H. BECQUE resigned his position as assistant superintendent of the U. S. Gypsum Co., Washington County, Virginia, Dec. 1, 1920, to accept a commission in the Chemical Warfare Service, Edgewood Arsenal, Edgewood, Md.

HENRY W. BLAKE, senior editor of the *Electric Railway Journal*, was tendered a dinner by his associates in the McGraw-Hill Co. on Jan. 6 in celebration of Mr. Blake's completion of thirty years of editorial work on this magazine. Mr. Blake graduated as civil engineer at Yale University in 1886 and as electrical engineer at the Massachusetts Institute of Technology in 1888, and consequently brought to his editorial work a degree of technical knowledge unusual in those days.

F. E. COOMBS, consulting engineer, San Francisco, is doing supervisory work for the Asti Grape Products Co., which is installing a grape-sirup manufacturing plant at its winery in Asti, Cal.

LOUIS P. DESTRIBATS, of Trenton, N. J., has resigned as general manager of the Ajax Rubber Co., which operates a large plant in Trenton, N. J. The position is now being filled by A. J. McMann, of Detroit, who has been connected with the company for some time. He formerly was affiliated with the United States Tire Co. Mr. Destribats retains his connection as vice-president and director of the company.

J. A. HYNES, of the U. S. Custom House, spoke before the Chicago Chemists' Club recently on "Some Problems of the Customs Chemist."

ALVA N. JAMES, of Evanston, Ill., has just returned from an extensive trip to the Chilean nitrate fields and copper properties.

WALTER L. JORDAN, formerly chemical engineer of the Celite Products Co., has opened an office in New York City as a consulting chemical engineer and is now carrying on work on filtration.

DAYTON C. MILLER, of the Case School of Applied Science, spoke before the Detroit Engineering Society Jan. 7, on "Photographing the Flash From Large Guns and Projectiles."

STEPHEN SCHWARTZ, formerly of the Empire Refineries, is now in charge of the engineering and construction department of the Indiana Oil Refining Co., Columbus, Ind., which concern will erect a refinery complete with lubricating oil department.

PAUL C. SKINNER, general manager of the General Chemical Co.'s plant, Denver, Col., is making an extended business trip to New York City and the East.

H. G. THIELE is superintendent of the Borosolvay potash plant of the Solvay Process Co. at Borosolvay, Cal.

R. C. TOLMAN, director of the Fixed Nitrogen Laboratories, War Department, addressed the Chemical Society of Washington, on Jan. 13, on the subject, "The Third Law of Thermodynamics."

HAROLD VANDOREN, formerly with the Grasselli Chemical Co., has accepted a position as research chemist with the Koppers Co., Pittsburgh, Pa.

Current Market Reports

The Chemical and Allied Industrial Markets

New York, Jan. 17, 1921.

Improved inquiries and orders from miscellaneous sources resulted in a more active state of business in the chemical market. For the first time in many weeks trade sentiment is cheerful and it is believed that the continued strength among some of the leading chemicals will do a great deal to stimulate confidence in the general market.

Buyers are experiencing great difficulty in placing orders on *soda ash* and *caustic soda*, owing to the pronounced scarcity of offerings and the advancing tendency in prices. At the close of the week light ash was stronger than it has been in the past six months and it was exceptionally hard to find a resale lot of any sizable dimension. Those affiliated with the resale distributors of soda ash had to pass up business in several instances and it is known that orders were placed with producers at $2.20 per 100 lb. f.o.b. works flat. Export parcels in the open market were quoted as high as 2¼c. per lb., although no sales were recorded as far as could be learned above $2.20. As was expected, the advance in soda ash was directly reflected on the market for caustic soda. Sales for the latter chemical have been made as high as 4c. per lb. This is the highest price recorded since early November. Some large sellers of caustic soda stated that there is only enough resale material available to cover wants for a short time, and that unless producers reduce the price of contracts, they will be compelled to rely upon first hands to cover their requirements.

Spot *bichromate of soda* was quoted firm with sellers asking 9¼@9¾c. per lb. for standard material. Dealers stated that only a few small lots could be purchased around the inside figures. A little better inquiry seems to be developing for this material and it looked as though any real buying would strengthen prices. Sellers are not inclined to accept February shipment orders except at about 1c. per lb premium over spot prices. Sales of foreign *muriate of potash* were reported at $75 per ton, basis 80 per cent, delivered. Both foreign and domestic muriate appear to be on a parity at the present time. Quotations ranged from $75 to $80 per ton, according to seller. Some interests assert that a keener competition is developing among the sellers of this chemical, although prices have not changed since the first of the year. Resale lots of *bichromate of potash* were on the market at 16@17c. per lb., spot New York. In some quarters it was intimated that a firm offer of 15c. per lb. would probably be accepted for moderate quantities. Inquiry for this chemical has not been active of late and second-hand competition has resulted in the lowering of the spot quotations. While in some quarters 17c. per lb. for *prussiate of soda* was reported acceptable for limited quantities, in others the market was quoted at 17½c. It is possible that small isolated lots can be purchased a shade under these figures, but the general tone was reported slightly firm with a fair amount of small lot business passing.

Off lots of *oxalic acid* were on the market at 80c. per lb. Sellers' views covered the same wide range lately recorded and some producers are asking 25c. per lb. for material exstore. The general feeling is firm and some interests assert that actual supplies are relatively small. Reports from some quarters on the export situation of *alcohol* are becoming more optimistic and not only is there a greater number of scattered inquiries, but shipments to some ports are increasing in volume. The domestic demand is confined to small lots on the basis of $5@$5.50 per gal. Producers quoted *denatured alcohol* at 68@77c. per gal., depending on formula. The demand is of small volume and some holders are said to be shading where business was possible. Trading in *wood alcohol* remained quiet, although a better inquiry was recently noted. Prices ranged from $1.30 to

$1.60 per gal., depending on grade. The general aspect of the *glycerine* market was stronger and trading reflected more activity. A fair volume of the c.p. grade moved into consuming channels on the basis of 20c. per lb. in drums and 22c. in tins.

Coal-Tar Market

General conditions seemed to have improved somewhat during the last week in some of the markets that coal-tar products are more or less dependent on. From both local and foreign quarters inquiries have been increasing and many are of the opinion that these inquiries mean real business in the very near future.

Crude producers are candid in stating that there is nothing in the line of large lot business, but small orders are coming in more frequently. Prices are holding steady with prospects of a future demand that will further stabilize the market.

Few inquiries were reported for *dinitrobenzene* and the market continued dull. Supplies were abundant, but outside of occasional small lot offerings at reduced prices, first-hand quotations were holding fairly steady. Spot material ranged from 25c. to 30c. per lb., depending on quantity and sellers. The only activity on *dinitroclorbenzene* is occasional small lot sales. There were few buyers and these were interested in small quantities only. Prices, however, were held steady at 27@30c. per lb. The market in *para-dichlorbenzene* reflected a firm tendency with supplies quoted in car lots at 10c. per lb., and ranging up to 14c. per lb. for lesser quantities. A steady improvement in the demand is looked for, now that conditions in the textile centers are clearing.

Consumers showed little interest in the market on *para-nitraniline*. Producers reported regular supplies available on spot. Prices ranged from 93c. to $1 per lb. Very little *paraphenylenediamine* is being moved at present on account of most of the large fur dyers being closed. Stocks are not pressing, however, and prices are fairly well held by producers. The average price is $2.20 per lb., with some variation noted at both higher and lower levels. Second hands are offering *naphthalene flakes*, 79-81 m.p., American make, at 8c. per lb. spot. Producers are quoting contract and future delivery on the basis of 9c. per lb. Trading in *beta naphthol* continued along quiet lines. Producers are holding steady to the present quotations of 45@50c. per lb. Offerings in second hands are still hovering around the market at much lower prices. Factors reported a regular supply of *monochlorbenzene* on the basis of 14c. per lb. in carload lots and while sales are of a light routine nature as yet, the conditions of the consuming end are much brighter for an increased demand.

Rubber Market

Little variation was noted in crude rubber prices throughout the week. Spot *ribbed smoked* sheets were offered quite freely at 20c. per lb., but as far as could be ascertained no business was transacted at this level. Sellers of January are also asking 20c. per lb. Futures remained nominally unchanged with sellers scarce and a fair amount of inquiries received. January-March closed at 21c., April-June at 22½c., and July-December at 25½@26c. One factor reported a small lot sale for April-June at 22c.

Naval Stores

There is a firm belief in the trade that buying interest in the near future will increase and prices were advanced by leading interests. A boost of 6c. per gal. on *turpentine* was noted during the week which is now quoted at 75c. per gal. *Rosin*, however, while firmer, remained quoted at former levels. Trading during the week in general showed a moderate increase in small lot business. The Savannah market has not been subject to any change and remained stagnant with no sales reported in either turpentine or rosins.

Correction

In our issue of Jan. 5 we published a table on sodium compounds for 1918-1919 in which we erroneously transposed figures. The following is a correct table of the various important sodium compounds produced during 1918-1919:

	1918 Short Tons	1919 Short Tons
Sodium Acetate	2,622	2,426
Sodium Bicarbonate	118,535	134,962
Sodium Bichromate	28,334	26,526
Soda Ash	1,390,628	981,054
Sodium Ferrocyanide	4,525	3,437
Sodium Hydroxide	513,363	355,466

The Baltimore Market

Baltimore, Md., Jan. 11, 1921.

The expected improvement in the market on fertilizer materials has not yet materialized. Purchases continued to be made on a "hand-to-mouth" basis, and trading is generally in small parcels. Heavy liquidation of stocks held by manufacturers is not to be noted. In fact most of the local fertilizer factories have been closed down since the first of the year and it is thought that normal operations will not be resumed for at least a few weeks. Merchants and speculators, however, are forced by necessity to place some of their materials on the market. These forced sales are being made at prices under nominal quotations.

Fertilizer salesmen are reporting but indifferent success in their campaign for spring business. In certain sections the farmers' organizations have entered into agreements to delay purchasing until fertilizer prices are lowered or prices on farm products are increased.

Acid Phosphate—Acid phosphate can be purchased at $16 per ton, basis 16 per cent bulk, run of pile. The nominal quotation, however, is about fifty cents per ton above this figure. Raw rock is said to be moving from the mines more rapidly than was the case a few months ago.

Nitrate of Soda—Importers' quotations on this commodity are nominal at $2.85 per 100 lb. ex-vessel Atlantic ports. Resale lots, however, can be obtained at $2.75.

Sulphate of Ammonia—Resale lots of sulphate are now offered at $3.75 per 100 lb., which marks a decline of 25c. since last report. This quotation governs on bagged material in carload lots.

Potash—There are rather heavy stocks of foreign potash in local warehouses at present. It is believed, however, that a surplus does not exist as deliveries from now on will be light. It is also reported that many of the manufacturers have not covered their requirements. The market is quoted nominal; muriate, $1.70 per unit; kainit and manure salts. $1.50 per unit. All ex-vessel Atlantic ports. Nebraska potash can be had at a slight premium over the foreign goods.

Fish Scrap—Very little fish scrap has moved since last report. The nominal market has declined 25c. per unit, being now quoted at $3.75 and 10c. delivered Baltimore in buyers' bags. There are available stocks at the fish factories. Ground scrap sold this week at $4 and 10c. Baltimore. Prime A menhaden fish oil can be had at 30c. per gal. in tierces delivered Baltimore.

The Iron and Steel Market

Pittsburgh, Pa., Jan. 14, 1921.

Demand in the open market for steel products has not visibly increased. On the whole, demand against old contracts is tending to decrease. With the independents there have been some reinstatements of business, or "releases" in connection with shipping orders previously suspended, the releases being prompted by the revision of contract prices recently down to the Steel Corporation or Industrial Board level, but these hardly make up for the completion from time to time of old orders. With the Steel Corporation, there are still full shipments against contracts on books, but it is apparent that the corporation's customers are not consuming steel in all cases altogether as fast as steel is being received, and an early increase in the rate of consumption will be requisite to forestall a decrease in the Steel Corporation's rate of production and shipments.

Such an increase is not to be expected within the next few weeks. The predictions made in December, that there would be a distinct increase in steel demand immediately after the first of the new year, were probably made from habit. There are many precedents for the making of such a

prediction in December, but there are no precedents for steel demand to increase in January. March or April, and September or October, are the established times for the steel market to broaden. At present, the more sanguine predict a decided improvement in demand before the end of March. Others doubt whether there will be any material improvement before late in the year, if in this year at all.

It is a new situation, or at least a new one for the present generation. The country is not, apparently, suffering from over-expansion in material development, in railroads, office and hotel buildings and dwelling houses. It does not seem to be overstocked with goods, except perhaps in some goods upon which wholesalers or retailers refuse to take the necessary loss, and of course excepting copper, which stands in altogether unique position and must not be used as a basis for generalizing. There is no very serious credit strain, as testified by the smallness of business failures. In other periods of depression and readjustment a decline in prices was essential, but the operation was distinctly subsidiary. Now the principal thing is a great readjustment in values of all commodities and in wage rates and compensation for personal service of various descriptions. It is known what needs to be done, but from lack of precedent it is difficult to estimate the length of time that will be required. The time may prove much shorter than many now estimate, for it is largely a matter of men changing their minds. Experience is still fresh as to how rapidly men can do that in one direction. Why not rapidly in the other?

Steel Corporation Tonnage

The Steel Corporation's unfilled obligations decreased by 873,359 tons during December. The first decrease was in August, and the decreases have steadily grown larger. There were fair bookings in December, however, for while the decrease in unfilled obligations represented 64 per cent of capacity for the month the shipments may be estimated at about 94 per cent, production being at about 92 per cent, while there was a large movement of tubular goods accumulated, in addition to the current output. Thus the net bookings must have been about 30 per cent, total bookings being in excess of this, in offset of cancellations, of which there certainly were some. The independents, although their order books were almost bare, had light bookings. There is no trend, as was expected by some, for buyers to leave the corporation and patronize independents, while on the other hand there are some instances of buyers, formerly customers of independents, now seeking to obtain a place as Steel Corporation customers.

Prices

At various times from the middle of November to the end of December the independent market on the different steel products receded to the Steel Corporation or Industrial Board level. The markets are now steady at those prices. There is occasional shading in some commodities by independents, but this shading is distinctly exceptional. The majority of independents are firm in their price views, while the Steel Corporation, with well-filled order books, has no occasion to give the subject a thought.

It is a fair statement that the independents do not cut prices because there is no sufficiently attractive business in sight. Some independents might cut the price on a commodity to secure one fair-sized order, but in general the attitude is that price cutting would not pay. As between operating at 20 to 50 per cent, which is the prevailing range with plants that are not closed entirely, at present prices, and operating at 80 to 100 per cent at prices quite a number of dollars a ton below the present level, the choice would no doubt be instant. When such an operation becomes a possibility the whole price structure in the steel market will be recast if necessary to attain the end.

Steel ingot production in December was at the rate of about 21,000,000 tons a year by the Steel Corporation and at about 10,000,000 tons a year by the independents, or 31,000,000 tons altogether. Independent operations decreased rather steadily during December, but the rate now is about the same as that at the end of December, say 7,000,000 or 8,000,000 tons, while the Steel Corporation's rate remains at about 21,000,000 tons.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..... –	$0.55 – $0.60
Acetone	lb.	$0.13 – $0.13½	.13½ – .14
Acid, acetic, 28 per cent	100 lbs.	3.00 – 3.25	3.50 – 3.75
Acetic, 56 per cent	100 lbs.	6.00 – 6.25	6.50 – 6.75
Acetic, glacial, 99½ per cent, carboys	100 lbs.	10.50 – 11.00	11.25 – 11.50
Boric, crystals	lb.	.14½ – .15	.15½ – .16
Boric, powder	lb.	.15½ – .16½	.17 – .18
Citric	lb.	..... –	.50 – .52
Hydrochloric	100 lb.	1.85 – 2.25	2.75 – 3.00
Hydrofluoric, 52 per cent	lb.	.15 – .16	.16½ – .18
Lactic, 44 per cent tech	lb.	.10 – .11	.11½ – .12
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P.	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)		..... –	..... – .....
Nitric, 40 deg.	lb.	.07 – .07½	.08 – .08¼
Nitric, 42 deg.	lb.	.08½ – .09	.09½ – .10
Oxalic, crystals	lb.	.18¼ – .18½	.19 – .20
Phosphoric, Ortho, 50 per cent solution	lb.	.18 – .18½	.18¼ – .19
Picric	lb.	.28 – .35	.40 – .50
Pyrogallic, resublimed	lb.	..... –	2.30 – 2.40
Sulphuric, 60 deg., tank cars	ton	..... –	..... – .....
Sulphuric, 60 deg., drums	ton	..... –	14.00 – 15.00
Sulphuric, 66 deg., tank cars	ton	18.00 – 19.00	..... – .....
Sulphuric, 66 deg., drums	ton	21.00 – 22.00	22.50 – 23.00
Sulphuric, 66 deg., carboys	ton	..... –	..... – .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	23.00 – 24.00	..... – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	25.00 – 26.00	26.50 – 27.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 – .....
Tannic, U. S. P.	lb.	..... –	1.30 – 1.35
Tannic (tech.)	lb.	.48 – .50	.51 – .52
Tartaric, crystals	lb.	..... –	.33 – .35
Tungstic, per lb. of WO	lb.	..... –	1.20 – 1.40
Alcohol, Ethyl	gal.	..... –	5.00 – 5.50
Alcohol, Methyl (see methanol)		..... –	..... – .....
Alcohol, denatured, 188 proof	gal.	..... –	.68 – .72
Alcohol, denatured, 190 proof	gal.	..... –	.73 – .77
Alum, ammonia lump	lb.	.04½ – .04¾	.05 – .05½
Alum, potash lump	lb.	.05½ – .06	.06½ – .07
Alum, chrome lump	lb.	.13 – @13½	.14 – .14½
Aluminum sulphate, commercial	lb.	.02¾ – .03	.03½ – .03¾
Aluminum sulphate, iron free	lb.	.03½ – .03¾	.04 – .04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.06½ – .07	.07½ – .08¼
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 – .32	.33 – .35
Ammonium carbonate, powder	lb.	.12½ – .12¾	.13 – .13½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.09½ – .10	.10½ – .10¾
Ammonium chloride, granular (gray salammoniac)	lb.	.09¼ – .09½	.09¾ – .10
Ammonium nitrate	lb.	.09 – .09½	.10 – .10½
Ammonium sulphate	lb.	.03½ – .03¾	.04 – .04½
Amylacetate	gal.	..... –	4.25 – 4.50
Amylacetate tech	gal.	..... –	3.50 – 3.75
Arsenic oxide, lumps (white arsenic)	lb.	.10½ – .11	.11¼ – .11½
Arsenic, sulphide, powdered (red arsenic)	lb.	.15 – .15½	.15 – .16
Barium chloride	ton	75.00 – 80.00	85.00 – 90.00
Barium dioxide (peroxide)	lb.	.24 – .25	.26 – .27
Barium nitrate	lb.	.10 – .10½	.10½ – .11
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calc. hypochlorite)		..... –	..... – .....
Blue vitriol (see copper sulphate)		..... –	..... – .....
Borax (see sodium borate)		..... –	..... – .....
Brimstone (see sulphur, roll)		..... –	..... – .....
Bromine	lb.	.50 – .52	.54 – .56
Calcium acetate	100 lbs.	2.00 – 2.05	..... – .....
Calcium carbide	lb.	.04 – .04½	.04½ – .05
Calcium chloride, fused, lump	ton	27.00 – 29.00	30.00 – 32.00
Calcium chloride, granulated	lb.	.02 – .02½	.02½ – .03
Calcium hypochlorite (bleach'g powder)	lb.	.02¼ – .03	.03¼ – .03½
Calcium peroxide	lb.	..... –	1.25 – 1.30
Calcium phosphate, monobasic	lb.	..... –	.16 – .18
Calcium sulphate, pure	lb.	..... –	.05 – .06
Camphor	lb.	..... –	.88 – .90
Carbon bisulphide	lb.	.08 – .08½	.09 – .09½
Carbon tetrachloride, drums	lb.	.11 – .11¼	.11½ – .12
Carbonyl chloride (phosgene)	lb.	..... –	.60 – .75
Caustic potash (see potassium hydroxide)		..... –	..... – .....
Caustic soda (see sodium hydroxide)		..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	..... –	.43 – .50
Cobalt oxide	lb.	..... –	3.90 – 4.00
Copperas (see iron sulphate)		..... –	..... – .....
Copper carbonate, green precipitate	lb.	.22 – .22½	.24 – .25
Copper cyanide	lb	..... –	.40 – .50
Copper sulphate, crystals	lb.	.06½ – .06½	.06¾ – .07
Cream of tartar (see potassium bitartrate)		..... –	..... – .....
Epsom salt (see magnesium sulphate)		..... –	..... – .....
Ethyl Acetate Com. 85%	gal.	..... –	1.05 – 1.10
Ethyl Acetate pure (acetic ether 98% to 100%)		..... –	..... – .....
Formaldehyde, 40 per cent	lb.	.18½ – .18	.19 – .19½
Fusel oil, ref.	gal.	..... –	3.50 – 3.60
Fusel oil, crude	gal.	..... –	2.75 – 3.00
Glauber's salt (see sodium sulphate)		..... –	..... – .....
Glycerine, C. P. drums extra	lb.	..... –	.20 – .21
Iodine, resublimed	lb.	..... –	3.85 – 4.00
Iron oxide, red	lb.	..... –	.10 – .20
Iron sulphate (copperas)	100 lb.	1.50 – 1.75	2.00 – 2.25
Lead acetate, normal	lb.	..... –	.14 – .16
Lead arsenate (paste)	lb.	.13 – .14	.14 – .15
Lead nitrate, crystals	lb.	..... –	.90 – 1.00
Litharge	lb.	.09 – .09¼	.09½ – .10
Lithium carbonate	lb.	..... –	1.50 – .....
Magnesium carbonate, technical	lb.	.10½ – .11	.11½ – .12
Magnesium sulphate, U. S. P.	100 lb.	2.50 – 3.00	..... – .....
Magnesium sulphate, commercial	100 lb.	..... –	1.50 – 1.75
Methanol, 95%	gal.	..... –	1.30 – 1.40
Methanol, pure	gal	..... –	1.50 – 1.70
Nickel salt, double	lb.	..... –	.12 – .12½
Nickel salt, single	lb.	..... –	.13 – .13½
Phosgene (see carbonyl chloride)		..... –	..... – .....
Phosphorus, red	lb.	.45 – .46	.47 – .50
Phosphorus, yellow	lb.	..... –	.35 – .37
Potassium bichromate	lb.	.16 – .16½	.16½ – .17

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$ — $	$0.37 — $0.38
Potassium bromide, granular	lb.	—	.25 — .40
Potassium carbonate, U. S. P.	lb.	.35 — .40	.45 — .50
Potassium carbonate, crude	lb.	.11 — .11½	.11½ — .12
Potassium chlorate, crystals	lb.	.10 — .11	.12 — .18
Potassium cyanide	lb.	—	.65 — .70
Potassium hydroxide (caustic potash)	lb.	.14 — .14½	.15 — .16
Potassium muriate	ton	75.00 — 80.00	—
Potassium iodide	lb.	—	3.00 — 3.20
Potassium nitrate	lb.	.11½ — .12	.12½ — .13
Potassium permanganate	lb.	.60 — .63	.65 — .70
Potassium prussiate, red	lb.	.50 — .52	.53 — .55
Potassium prussiate, yellow	lb.	.31 — .31½	.32 — .33
Potassium sulphate (powdered)	ton	$225.00 — 230.00	—
Rochelle salts (see sodium potas. tartrate)		—	—
Salammoniac (see ammonium chloride)		—	—
Sal soda (see sodium carbonate)		—	—
Salt cake	ton	—	33.00 — 35.00
Silver cyanide	oz.	—	1.25 —
Silver nitrate	oz.	—	.43 — .45
Soda ash, light	100 lb.	2.05 — 2.15	2.20 — 2.50
Soda ash, dense	100 lb.	2.50 — 2.60	2.70 — 3.00
Sodium acetate	lb.	.05½ — .05½	.06 — .06½
Sodium bicarbonate	100 lb.	2.40 — 2.50	2.60 — 2.90
Sodium bichromate	lb.	.09¼ — .09½	.09½ — .10
Sodium bisulphate (nitre cake)	ton	7.00 — 7.50	8.00 — 11.00
Sodium bisulphite powdered, U.S.P.	lb.	.06½ — .07	.07½ — .08
Sodium borate (borax)	lb.	.07 — .07½	.07¾ — .08
Sodium carbonate (sal soda)	100 lb.	2.00 — 2.25	2.50 — 2.75
Sodium chlorate	lb.	.10 — .10½	.10½ — .11
Sodium cyanide, 96-98 per cent	lb.	.21 — .23	.24 — .30
Sodium fluoride	lb.	.17 — .17½	.17½ — .18½
Sodium hydroxide (caustic soda)	100 lb.	3.90 — 4.00	4.10 — 4.60
Sodium hyposulphite	lb.	—	.04 — .04¼
Sodium nitrate	cwt.	2.85 —	3.00 —
Sodium nitrite	lb.	.06 — .06	.06½ — .07
Sodium peroxide, powdered	lb.	.30 — .31	.32 — .34
Sodium phosphate, dibasic	lb.	.03¾ — .04½	.04½ — .05
Sodium potassium tartrate (Rochelle salts)	lb.	—	.33 — .35
Sodium prussiate, yellow	lb.	.17 — .17½	.17½ — .18
Sodium silicate, solution (40 deg.)	lb.	.01½ — .01½	.02 — .02½
Sodium silicate, solution (60 deg.)	lb.	.03 — .03½	.03½ — .04
Sodium sulphate, crystals (Glauber's salt)	100 lb.	1.75 — 2.00	2.25 — 2.50
Sodium sulphide, crystal, 60-62 per cent (conc.)	lb.	.05½ — .05½	.06 — .06½
Sodium sulphite, crystals	lb.	.04 — .04½	.04½ — .05
Strontium nitrate, powdered	lb.	.20 — .20½	.21 — .22
Sulphur chloride, red	lb.	.08 — .09	.10 — .10½
Sulphur, crude	ton	16.00 — 20.00	—
Sulphur dioxide, liquid, cylinders	lb.	.09 —	.10 — .12
Sulphur (sublimed), flour	100 lb.	—	3.70 — 4.35
Sulphur, roll (brimstone)	100 lb.	—	3.40 — 3.90
Tin bichloride, 50 per cent	lb.	.18 — .19	—
Tin oxide	lb.	—	.50 — .51
Zinc carbonate, precipitate	lb.	.16 — .18	.19 — .20
Zinc chloride, gran.	lb.	.11½ — .12	.12½ — .13
Zinc cyanide	lb.	.45 — .49	.50 — .60
Zinc dust	lb.	.12 — .13	.13½ — .14
Zinc oxide, XX	lb.	.10 — .10½	.11 — .11½
Zinc sulphate	lb.	.03½ — .03¾	.04 — .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.10 — $1.15
Alpha-naphthol, refined	lb.	1.45 — 1.50
Alpha-naphthylamine	lb.	.40 — .44
Aniline oil, drums extra	lb.	.23 — .25
Aniline salts	lb.	.27 — .30
Anthracene, 80% in drums (100 lb.)	lb.	.85 — 1.00
Benzaldehyde (f.f.c.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.00 — 1.10
Benzidine sulphate	lb.	.85 — .90
Benzoic acid, U.S.P.	lb.	.70 — .75
Benzoate of soda, U.S.P.	lb.	.75 — .85
Benzene, pure, water-white, in drums (100 gal.)	gal.	.30 — .35
Benzene, 90%, in drums (100 gal.)	gal.	.28 — .32
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech.	lb.	.25 — .35
Beta-naphthol benzoate	lb.	3.50 — 4.00
Beta-naphthol, sublimed	lb.	.75 — .80
Beta-naphthol, tech (nominal)	lb.	.38 — .42
Beta-naphthylamine, sublimed	lb.	2.25 — 2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 — 1.00
Cresylic acid, 75-97%, dark, in drums	gal.	.90 — .95
Cresylic acid, 50%, first quality, drums	gal.	.65 — .75
Dichlorbenzene	lb.	.06½ — .15
Diethylaniline	lb.	1.25 — 1.30
Dimethylaniline	lb.	.65 — .90
Dinitrobenzene	lb.	.27 — .30
Dinitroclorbenzene	lb.	.25 — .30
Dinitronaphthalene	lb.	.35 — .40
Dinitrophenol	lb.	.40 — .45
Dinitrotoluene	lb.	.27 — .30
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .40
Diphenylamine	lb.	.70 — .75
H-acid	lb.	1.40 — 1.55
Meta-phenylenediamine	lb.	1.25 — 1.30
Monochlorbenzene	lb.	.14 — .16
Monoethylaniline	lb.	1.75 — 2.25
Naphthalene crushed, in bbls. (250 lb.)	lb.	.08 — .08½
Naphthalene, flake	lb.	.08 — .08½
Naphthalene, balls	lb.	.09 — .09½
Naphthionic acid, crude	lb.	.70 — .75
Nitrobenzene	lb.	.12 — .15
Nitro-naphthalene	lb.	.40 — .50
Nitro-toluene	lb.	.18 — .25
Ortho-amidophenol	lb.	3.20 — 3.75
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.75 — .80
Ortho-nitro-toluene	lb.	.23 — .30
Ortho-toluidine	lb.	.25 — .30
Para-amidophenol, base	lb.	1.90 — 2.00
Para-amidophenol, HCl	lb.	2.20 — 2.25
Para-dichlorbenzene	lb.	.10 — .15
Paranitroaniline	lb.	.93 — 1.00
Para-nitrotoluene	lb.	1.25 — 1.40
Para-phenylenediamine	lb.	2.20 — 2.35
Para-toluidine	lb.	1.70 — 1.80
Phthalic anhydride	lb.	.55 — .60
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.09 — .10
Pyridine	gal.	2.00 — 3.50
Resorcinol, technical	lb.	2.50 — 2.60
Resorcinol, pure	lb.	3.60 — 3.80
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.25 — .28
Salicylic acid, U. S. P.	lb.	.29 — .35
Salol	lb.	.85 — .95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.28 — .32
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.16 — .18
Sulphanilic acid, crude	lb.	.30 — .35
Toluidine	lb.	1.35 — 1.40
Toluidine, mixed	lb.	.40 — .45
Toluene, in tank cars	gal.	.30 — .32
Toluene, in drums	gal.	.33 — .35
Xylidines, drums, 100 gal.	lb.	.45 — .50
Xylene, pure, in drums	gal.	.42 — .45
Xylene, pure, in tank cars	gal.	.45 —
Xylene, commercial, in drums, 100 gal.	gal.	.33 — .35
Xylene, commercial, in tank cars	gal.	.30 —

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.24 — $0.26
Beeswax, refined, light	lb.	.27 — .28
Beeswax, white pure	lb.	.35 — .40
Carnauba, No. 1	lb.	.85 — .90
Carnauba, No. 2, North Country	lb.	.35 — .40
Carnauba, No. 3, North Country	lb.	.19 — .20
Japan	lb.	.19 — .20
Montan, crude	lb.	.07 — .08
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.05 — .05½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.04½ — .05½
Paraffine waxes, refined, 118-120 m.p.	lb.	.06 — .06½
Paraffine waxes, refined, 125 m.p.	lb.	.07¼ — .07½
Paraffine waxes, refined, 128-130 m.p.	lb.	.07¾ — .08
Paraffine waxes, refined, 133-135 m.p.	lb.	.09 — .09½
Paraffine waxes, refined, 135-137 m.p.	lb.	.10½ — .11
Stearic acid, single pressed	lb.	.13¼ — .13½
Stearic acid, double pressed	lb.	.13¾ — .14
Stearic acid, triple pressed	lb.	.14¼ — .14½

Flotation Oils

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.90
Pine oil, pure, dest. dist.	gal.	1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b. New York for carload lots.

Rosin B-D, bbl.	280 lb.	$8.75 —
Rosin E-I	280 lb.	8.75 —
Rosin K-N	280 lb.	8.75 —
Rosin W. G.-W. W.	280 lb.	9.00 —
Wood rosin, bbl.	280 lb.	9.00 —
Spirits of turpentine	gal.	.75 —
Wood turpentine steam dist.	gal.	.70 —
Wood turpentine, dest. dist.	gal.	.69 —
Pine tar pitch, bbl.	200 lb.	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	— 15.00
Retort tar, bbl.	500 lb.	15.00 — 15.50
Rosin oil, first run	gal.	.60 —
Rosin oil, second run	gal.	.62 —
Rosin oil, third run	gal.	.72 —

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.41
70-72 deg., steel bbls. (85 lb.)	gal.	.39
68-70 deg., steel bbls. (85 lb.)	gal.	.38
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.30

Crude Rubber

Para—Upriver fine	lb.	$0.18½ — $0.19
Upriver coarse	lb.	.14 — .14¼
Upriver caucho ball	lb.	.14½ — .14¾
Plantation—First latex crepe	lb.	.21 —
Ribbed smoked sheets	lb.	.20 —
Brown crepe, thin, clean	lb.	.18 —
Amber crepe No. 1	lb.	.20 —

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.09½ — $0.10½
Castor oil, AA, in bbls.	lb.	.11½ — .12
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.08½ — .09
Cocoanut oil, Ceylon grade, in bbls.	lb.	.12½ — .13
Cocoanut oil, Cochin grade, in bbls.	lb.	.13 — .13½
Corn oil, crude, in bbls.	lb.	.09 — .09½
Cottonseed oil, crude (f. o. b. mill)	lb.	.06 — .07
Cottonseed oil, summer yellow	lb.	.09 — .09¼
Cottonseed oil, winter yellow	lb.	.09¼ — .09½
Linseed oil, raw, car lots (domestic)	gal.	.76 — .77
Linseed oil, raw, tank cars (domestic)	gal.	.69 — .70
Linseed oil, boiled, car lots (domestic)	gal.	.78 — .79

Olive oil, commercial	gal.	$2 90 —	$3 00
Palm, Lagos	lb.	08 —	08½
Palm, Niger	lb.	07 —	07½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	07 —	07½
Peanut oil, refined, in bbls	lb.	13 —	13½
Rapeseed oil, refined in bbls	gal.	1 10 —	1 15
Rapeseed oil, blown, in bbls	gal.	1 20 —	1 25
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	08½ —	09
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	05¾ —	06
FISH			
Light pressed menhaden	gal.	$0 53 —	$0 55
Yellow bleached menhaden	gal.	55 —	58
White bleached menhaden	gal.	57 —	60
Blown menhaden	gal.	1 00 —	....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$24 00 —	30 00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	22 00 —	26 00
Barytes, crude, 88% @ 94% ba., Kings Creek	net ton	10 00 —	12 00
Barytes, floated, f.o.b. St. Louis	net ton	26 50 —	28 00
Barytes, crude, first grade, Missouri	net ton	10 00 —	....
Blanc fixe, dry	lb.	05 —	05½
Blanc fixe, pulp	net ton	60 00 —	65 00
Casein	lb.	14 —	18
Chalk, domestic, extra light	lb.	05 —	06
Chalk, domestic, light	lb.	04½ —	05½
Chalk, domestic, heavy	lb.	04 —	05
Chalk, English, extra light	lb.	05 —	07
Chalk, English, light	lb.	05 —	06
Chalk, English, dense	lb.	04½ —	05
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	8 00 —	10 00
China clay (kaolin) washed, f.o.b. Georgia	net ton	12 00 —	15 00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	18 00 —	22 00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8 00 —	12 00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	15 00 —	40 00
China clay (kaolin), imported, lump	net ton	25 00 —	35 00
China clay (kaolin), imported, powdered	net ton	30 00 —	35 00
Feld-spar, crude, f.o.b. Maryland and North Carolina points	gross ton	8 00 —	14 00
Feld-spar, crude, f.o.b. Maine	net ton	7 50 —	10 00
Feld-spar, ground, f.o.b. Maine	net ton	21 00 —	23 00
Feld-spar, ground, f.o.b. North Carolina	net ton	17 00 —	21 00
Feld-spar, ground, f.o.b. N. Y. State	net ton	17 00 —	21 00
Feld-spar, ground, f.o.b. Baltimore	net ton	27 00 —	30 00
Fullers earth, f.o.b. New York	net ton	16 00 —	17 00
Fullers earth, granular, f.o.b. Fla	net ton	25 00 —	....
Fullers earth, powdered, f.o.b. Fla	net ton	18 00 —	....
Fullers earth, imported, powdered	net ton	35 00 —	40 00
Graphite, crucible, 90% carbon, Ashland, Ala	lb.	.... —	09
Graphite, crucible, 85% carbon, Ashland, Ala	lb.	07 —	09
Graphite, higher lubricating grades	lb.	11 —	40
Pumice stone, imported, lump	lb.	04 —	50
Pumice stone, domestic lump	lb.	06 —	....
Pumice stone, ground	lb.	04 —	07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	.... —	10 00
Quartz (acid tower) 1¼@2 in., f.o.b. Baltimore	net ton	.... —	14 00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	.... —	17 00
Quartz, lump, f.o.b. North Carolina	net ton	5 00 —	7 50
Shellac, orange fine	lb.	80 —	85
Shellac, orange superfine	lb.	95 —	1 00
Shellac, A. C. garnet	lb.	70 —	75
Shellac, T. N	lb.	68 —	70
Soapstone	ton	15 00 —	25 00
Sodium chloride	long ton	.... —	17 50
Talc, paper-making grades, f.o.b. Vermont	ton	12 00 —	22 00
Talc, roofing grades, f.o.b. Vermont	ton	9 50 —	15 00
Talc, rubber grades, f.o.b. Vermont	ton	12 00 —	18 00
Talc, powdered, Southern, f.o.b. cars	ton	12 00 —	15 00
Talc, imported	ton	60 00 —	70 00
Talc, California talcum powder grade	ton	20 00 —	45 00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	1,000	160
Chrome brick, f.o.b. Eastern shipping points	net ton	100– 110
Chrome cement, 40–45% Cr_2O_3	net ton	55– 60
Chrome cement, 40–45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton	60– 65
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	55– 60
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	45– 50
Magnesite brick, 9-in. straight	net ton	110
Magnesite brick, 9-in. arches, wedges and keys	net ton	121
Magnesite brick, soaps and splits	net ton	134
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000	65– 70
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000	56– 61
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000	55–60

Ferro-Alloys

All f.o.b. Works

Ferrocarbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200 00 —	$225 00
Ferrochrome per lb. of Cr. contained, 6–8% carbon, carlots	lb.	16 —	17
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	17 —	18
Ferromanganese, 76-80% Mn, domestic	gross ton	110 00 —	115 00
Ferromanganese, 76-80% Mn, English	gross ton	130 00 —	135 00
Spiegeleisen, 18-22% Mn	gross ton	60 00 —	65 00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2 00 —	2 50
Ferrosilicon, 10-15%	gross ton	55 00 —	60 00
Ferrosilicon, 50%	gross ton	78 00 —	80 00
Ferrosilicon, 75%	gross ton	.... —	150 00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	55 —	.60
Ferrouranium, 35-50% of U, per lb. of U content	lb.	7 00 —	....
Ferrovanadium, 30-40% per lb. of contained V	lb.	6 50 —	7 50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content, less than 2% Fe_2O_3, up to 20% silica, not more than H 4% moisture	gross ton	$10 00 —	$11 00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	unit	60 —	65
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	unit	55 —	60
Coke, foundry, f.o.b. ovens	net ton	.... —	7 00
Coke, furnace, f.o.b. ovens	net ton	.... —	6 00
Coke, petroleum, refinery, Atlantic seaboard	net ton	21 00 —	22 00
Fluorspar, lump, f.o.b. Tonuco, New Mexico	net ton	17 50 —	....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	22 50 —	25 00
Ilmenite, 52% TiO_2, per lb. ore	lb.	01¼ —	01½
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	40 —	45
Manganese ore, chemical (MnO_2)	gross ton	60 00 —	65 00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	55 —	65
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	35 00 —	....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	12 —	....
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	17 —	....
Pyrites, domestic, fines, f.o.b. mines, Ga	unit	12 —	14
Rutile, 95% TiO_2 per lb. ore	lb.	15 —	....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	3 75 —	4 00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	4 00 —	4 25
Uranium ore (carnotite) per lb. of U_3O_8	lb.	2 75 —	3 00
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2 75 —	3 00
Vanadium pentoxide, 99%	lb.	12 00 —	14 00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1 50 —	....
Zircon, washed, iron free	lb.	05 —	....

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	15 00
Aluminum, 98 to 99 per cent	27 50
Antimony, wholesale lots, Chinese and Japanese	5 25@5 37½
Nickel, ordinary (ingot)	43 00
Nickel, electrolytic	45 00
Monel metal, spot and blocks	35
Monel metal ingots	38
Monel metal, sheet bars	40
Tin, 5-ton lots	34 02½
Lead, New York, spot	5 37½
Lead, E. St. Louis, spot	6 25
Zinc, spot, New York	7 00
Zinc, spot, E. St. Louis	6 75

OTHER METALS

Silver (commercial)	oz.	$0 66½
Cadmium	lb.	1 40@1 50
Bismuth (500 lb. lots)	lb.	2 40
Cobalt	lb.	6 00
Magnesium (f.o.b. Philadelphia)	lb.	1 35
Platinum	oz.	75 00
Iridium	oz.	350 00@400 00
Palladium	oz.	75 00
Mercury	75 lb.	50 00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	22 50
Copper bottoms	34 00
Copper rods	29 00
High brass wire and sheets	20 25
High brass rods	18 25
Low brass wire and sheets	30 50
Low brass rods	19 50
Brazed brass tubing	36 25
Brazed bronze tubing	41 50
Seamless copper tubing	26 00
Seamless high brass tubing	25 00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York — Current	New York — One Year Ago	Cleveland	Chicago
Copper, heavy and crucible	12 00	17 00	10 00	11 50
Copper, heavy and wire	11 50	16 00	9 50	11 00
Copper, light and bottoms	10 00	14 00	9 00	9 50
Lead, heavy	4 00	4 75	4 00	4 50
Lead, tea	3 00	3 75	3 00	3 50
Brass, heavy	7 00	10 50	7 00	10 50
Brass, light	5 50	7 50	5 00	5 50
No. 1 yellow brass turnings	6 50	10 00	5 50	5 50
Zinc	4 50	5 00	3 00	4 50

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York — Current	New York — One Month Ago	New York — One Year Ago	Cleveland — Current	Cleveland — One Year Ago	Chicago — Current	Chicago — One Year Ago
Structural shapes	$3 80	$4 15	$3 47	$3 58	$3 37	$3 58	$3 47
Soft steel bars	3 70	4 15	3 37	3 34	3 27	3 48	3 37
Soft steel bar shapes	3 70	4 15	3 37	3 48	3 27	3 48	3 37
Soft steel bands	4 65	5 50	4 07	6 25	....	....	....
Plates, ¼ to 1 in. thick	4 00	4 15	3.67	3 78	3 57	3 78	3.67

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

EL SEGUNDO — The General Chemical Co. is building a four-unit contract acid plant. This plant will go in operation some time soon.

Idaho

KELLOGG—The Bunker Hill and Sullivan Mining & Concentrating Co. plans to construct an electrolytic zinc refinery. Estimated cost, $1,000,000.

Illinois

KENNEY—The Kenney Community High School has awarded the contract for the construction of a 2-story, 104x106-ft. high school, to C. J. Newlin, Normal. Estimated cost, $84,000.

MARION—The Bd. of Local Impvts. will receive bids about March 15 for building sewerage system and sewage disposal plant. Estimated cost, $164,000. P. E. Wilson, city engr.

Iowa

PLEASANT PRAIRIE — Bd. Educ., Prairie (Fairport P. O.) is having plans prepared for the construction of a 2-story, 87x116-ft. consolidated school. A chemical laboratory will be installed in same. Estimated cost, $125,000. Notcott, Donnan & Notcott Co., 516 Black Bldg., Waterloo, archts.

Kansas

WICHITA—The Concrete Products Co., Caldwell Murdock Bldg., plans to construct a 2-story, 150x210-ft. cement plant and warehouse on Rock Island Ave. and 13th St. Estimated cost, $50,000. Archt. and engr. not selected.

Kentucky

CYNTHIANA—The city is having plans prepared for the construction and equipment of a filtration plant. Estimated cost, $25,000. J. T. Gillig, engr.

Louisiana

NEW ORLEANS — The Natl. Brewing Co., c/o C. A. Wagner, pres., 2600 Gravier St., has awarded the contract for converting its brewery on Dorgenois and Gravier Sts., into an alcohol manufacturing plant, and constructing a 1-story, 30x75-ft. fermenter building and 4-story, 30x54x75-ft. distillery building. Estimated cost, $140,000.

Massachusetts

EVERETT—J. Briggs & Co., Inc., manufacturer of paint, 45 Purchase St., Boston, is having plans prepared for the construction of a factory on Paris St., here. Estimated cost, $25,000.

WOBURN—F. C. Parker & Son, Inc., plans to rebuild tannery which was recently destroyed by fire. Loss $200,000.

Michigan

DETROIT—Park, Davis & Co., Atwater St. and McDougall Ave., plans to build a 4-story, 100x200-ft. drug factory. Above project is first unit of plant expansion to cost approximately $4,000,000. Smith, Hinchman & Grylls, 710 Washington Arcade, archts.

TRAVERSE CITY—The Traverse City General Hospital is having plans prepared for the construction of a 3-story, 50x300-ft. hospital. Laboratory equipment will be installed in same. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Detroit, archts.

Minnesota

EVELETH—The city plans to build disposal plant, septic tank and sewer extensions. Estimated cost, $500,000.

LITTLE FALLS—The Hennepin Paper Co., c/o C. E. Sager, Secy., 1128 Plymouth Rd., Minneapolis, plans to construct a sulphide paper factory here. Estimated cost, $500,000. Engineer not announced.

Missouri

CLAYTON—City will receive bids about April 1 for building sewers in sewer District 1, 2 and 3. A 50,000-gal. concrete septic tank will be installed in each. Noted Oc. 13.

KANSAS CITY—The C. & C. Developing Co., 705 Ridge Arcade, is building a refinery at 13th and Winchester Sts. This plant will increase its capacity to 1,500 bbl. per day within the next year.

New Jersey

PRINCETON—Boro. plans to construct a sewage disposal plant. Estimated cost, $30,000. C. P. Browne, mayor.

North Dakota

UNDERWOOD—The Bd. Educ. is having plans prepared for the construction of a 3-story, 80x120-ft. consolidated school. A chemical laboratory will be installed in same. Estimated cost, $100,000. W. D. Gillespie, Fargo, archt.

Ohio

AKRON—University of Akron, College of Engineering, plans to construct new building to include an engineering laboratory. Estimated cost, $100,000.

BUCKEYE LAKE—State Bd. Pub. Wks., Capitol, Columbus, and Licking Co. plan to construct a sewage disposal plant, here. Estimated cost, $75,000. Kenmor & Whitlock, State House, engrs.

FRANKLIN—The Bd. Educ. will open bids about March 1 for construction of a 3-story high and grade school. A chemical laboratory will be installed in same. Estimated cost, $170,000. G. H. Girke, supt. of schools.

WAUSEON — Bd. of Trustees, Pub. Affairs, will receive bids until Jan. 30 for the construction of a earthen reservoir, auxiliary pumping station and water filtration and sedimentation plant. Estimated cost, $25,000. W. T. Sherman & Co., Toledo, engrs.

Pennsylvania

BELLWOOD — The Natl. Steel Constr. Co., 237 4th Ave., Pittsburgh, purchasing the plant of the Bellwood Eng. Co., here, and plans to enlarge and equip same for the manufacture of electrical equipment for the production of fabricated steel plate. S. Kazorski, Bellwood, mgr.

South Dakota

PIERRE—The State plans to construct a cement plant at Lime Creek. Estimated cost, $100,000.

Texas

DALLAS—The Gulf Refining Co., Frick Annex, Pittsburgh, Pa., has awarded the contract for the construction of several 1- and 2-story buildings, to Bowden Constr. Co., Galveston. Cost between $150,000 and $200,000.

Wisconsin

BLACKCREEK—The Outagamie Limestone Co. is having plans prepared for the construction of a plant. J. B. Huhn, Secy.-Treas. H. O. Weldon, 10 La Salle St., Chicago, Ill., archt.

HARTFORD—City is having plans prepared for the construction of a sewage disposal plant and intercepting and storm sewers. Estimated cost, $100,000. J. Donohue, 608 North 8th St., Sheboygan, engr.

TAYCHEEDAH—The State Bd. of Control of Wisconsin, Capitol Bldg., Madison, receiving sealed proposals for furnishing 1 cold process water softener of 3,000 gal. per hour capacity for Wisconsin Industrial Home for Women, here. J. G. D. Mack, state ch. engr.

NEENAH—The Wolfax Co., Main St., plans to construct a 4-story, 60x150-ft. factory for the manufacture of pottery and porcelain ware. Estimated cost, $80,000. Architect not selected.

PLYMOUTH — City is having surveys made for a sewage disposal system. J. Donohue, 608 North 8th St. Sheboygan, engr.

REEDSBURG—Bd. Educ., c/o A. Bolson, plans to construct a 4-story, 60x185-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $125,000. Architect not selected.

British Columbia

VANCOUVER — The Harrison Pulp & Paper Co., will construct a mill for the manufacture of kraft paper at the mouth of the Harrison River. Estimated cost, $3,000,000.

New Brunswick

ST. GEORGE—The New York World Publishing Co., 63 Park Row, New York City, has purchased the plant of the St. George Pulp Co. here, and plans to enlarge same. The plans call for an increased output of from 30 to 100 tons daily.

Nova Scotia

HALIFAX—Silliker & McMann, Cragg Bldg., have purchased the pulp mill and timber property at Hartville and plan to rebuild the plant. P. H. Moore, local mgr.

WOLFVILLE — The Gaspereau River Light, Heat & Power Co. plans to build a 10-ton dry ground wood pulp mill.

Ontario

CORNWALL—The Can Linoleum & Oil Cloth Co., plans to construct a 2-story addition to its plant. Estimated cost, $35,000.

CORNWALL—The Howard Smith Paper Mills, Ltd., 138 McGill St., Montreal, will receive bids in the spring for enlarging its sulphate plant, here, increasing output to 50 tons daily.

IROQUOIS FALLS — Abitibi Power & Paper Co. plans to enlarge its plant. Estimated cost, $250,000.

PETERBOROUGH — City will receive bids about Feb. 1 for the construction of a 6,000,000-gal. filtration plant and a 2,000,000-gal. reservoir. Estimated cost, $350,000. R. L. Dobbin, water-works, supt.

PORT ARTHUR — The Kaministiqua Pulp & Paper Co., Ltd., will receive bids in the spring for building a new pulp mill which will have 250 tons daily capacity.

Coming Meetings and Events

AMERICAN CERAMIC SOCIETY will hold its annual meeting Feb. 21 to 24 at Columbus, Ohio, with headquarters at the Deschler Hotel.

AMERICAN CHEMICAL SOCIETY will hold its sixty-first meeting at Rochester, N. Y., April 26 to 29.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting at Atlantic City April 21 to 23 inclusive. Headquarters will be at the Hotel Chalfonte.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting Feb. 14 to 17 in New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 1921 annual meeting in the New Monterey Hotel, Asbury Park, N. J., during the week of June 20.

COMMON BRICK MANUFACTURERS' ASSOCIATION OF AMERICA will hold its annual meeting at the Hotel Pennsylvania, New York City, Jan. 31 to Feb. 4.

NATIONAL PETROLEUM CONGRESS will meet at the Hotel Baltimore, Kansas City, Mo., March 22 to 25.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

THE SEVENTH EXPOSITION OF CHEMICAL INDUSTRIES will be held during the week of Sept. 12, in the Eighth Coast Artillery Armory, New York City.

The following chemical societies will meet at Rumford Hall, Chemists' Club, New York City, as follows: Feb. 11, American Electrochemical Society, joint meeting with Society of Chemical Industry, American Chemical Society and Société de Chimie Industrielle; March 11, American Chemical Society, Nichols Medal award; March 25, Society of Chemical Industry; April 22, Society of Chemical Industry, joint meeting with American Electrochemical Society, Société de Chimie Industrielle and American Chemical Society; May 6, American Chemical Society; May 13, Société de Chimie Industrielle, joint meeting with American Chemical Society, Society of Chemical Industry and American Electrochemical Society; May 20, Society of Chemical Industry; June 10, American Chemical Society.